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COUNTER-IED INITIATIVE PPE HORIZON 0

PHASE 1 PROTECTION VERSUS PERFORMANCE PRELIMINARY TRADE-OFF ANALYSIS

BEHAVIOURAL TASK ANALYSIS

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Abstract

DRDC Valcartier has taken the lead on a Counter-IED (C-IED) Personal Protective Equipment (PPE) Horizon 0, which is a sub-project of a larger C-IED Technical Demonstration Project (TDP). DRDC Toronto is the providing Human Factors expertise to support this project. In order to develop PPE recommendations to overcome any change or increase in vulnerability a comprehensive understanding of physiological, biomechanical, task performance and operational impact of increasing coverage and/or level of protection of soldiers needs to be obtained. The objective of this study was to develop a number of operational scenarios that encompassed the majority of tasks performed by mounted crewmen. These scenarios were then used to conduct a behavioral task analysis (BTA) of vehicle crews with emphasis given to reach and viewing activities, physical motions and crew station operations, vehicle and equipment compatibility, and access/egress in normal and emergency situations. The operational scenarios were developed from a focus group held at CFB Edmonton from 1 – 2 February 2007. The four operational scenarios that were developed at the focus group were a quick reaction force in a close country, a broken down vehicle within a city, an engage targets scenario, and a vehicle-borne IED scenario. These scenarios were then used to lead the BTA that was conducted from 19 – 21 March 2007. A total of 28 soldiers participated in the BTA covering 8 vehicles (G-Wagon, MLVW, HLVW, TLAV, Bison, Leopard C2 Tank, Coyote, and the LAV III). Once the BTA was concluded each participant completed a questionnaire evaluating their current in-service personal protective equipment.

The BTA found that in most vehicle crew positions a full range of motion from the waist up is required, a critical design criteria for any additional PPE developed for vehicle crews. In general, existing PPE was acceptable but concerns were raised about the level of coverage on the sides, neck, throat and pelvis. There were also concerns about the in-service shoulder cap.

Résumé

RDDC Valcartier a pris le commandement d'une initiative d'équipement de protection individuelle (EPI) pour la lutte aux IED (C-IED) horizon 0, qui est un sous-projet d'un Programme de démonstration de technologie (PDT) de C-IED plus important. RDDC Toronto fournit les connaissances spécialisées en ergonomie pour soutenir ce projet. Afin de formuler des recommandations relativement à l'EPI pour corriger toute augmentation de la vulnérabilité, il faut obtenir une compréhension générale de l'incidence sur la physiologie, la biomécanique, le rendement de tâches et les opérations de l'augmentation de la couverture/de la protection des soldats. L'objectif de cette étude consistait à élaborer un certain nombre de scénarios opérationnels qui comprenaient la majorité des tâches accomplies par les membres d'équipage embarqués. Ces scénarios ont ensuite été utilisés pour effectuer une analyse comportementale des tâches sur les équipages de véhicules qui a mis l'accent sur la portée et les activités de surveillance, les mouvements physiques et les opérations du poste d'équipage, la compatibilité du véhicule et de l'équipement ainsi que l'accès/l'évacuation dans des situations normales et d'urgence. Les scénarios opérationnels ont été élaborés par un groupe de discussion qui a été réuni à la BFC Edmonton les 1er et 2 février 2007. Les quatre scenarios opérationnels qui ont été mis au point par le groupe de discussion sont les suivants : une force de réaction rapide sur un terrain couvert, un véhicule en panne dans une ville, un scénario d'engagement de cibles et un scénario de dispositif explosif de circonstance placé dans un véhicule. Ces scénarios ont ensuite été utilisés pour orienter l'analyse comportementale des tâches qui a été réalisée du 19 au 21 mars 2007. Dans l'ensemble, 28 soldats ont participé à l'analyse étudiant 8 véhicules (G-Wagon, VLMR, VLLR, VBLC, Bison, char Leopard C2, Coyote et VBL III). Lorsque l'analyse comportementale des tâches a été terminée, chaque participant a rempli un questionnaire qui évaluait leur équipement de protection individuel actuel.

L'analyse comportementale des tâches a conclu qu'une pleine amplitude de mouvements de la taille en montant est requise pour la plupart des postes de l'équipage de véhicule, ce qui constitue un critère de conception critique pour tout EPI supplémentaire développé pour l'équipage de véhicule. En général, L'EPI existant était acceptable mais des préoccupations furent soulevées concernant le niveau de protection sur les côtés, le cou, la gorge et le bassin. Il y avait également des préoccupations concernant l'épaulette présentement en service.

Executive Summary

DRDC Valcartier has taken the lead on a Counter-IED (C-IED) Personal Protective Equipment (PPE) Horizon 0, which is a sub-project of a larger C-IED Technical Demonstration Project (TDP). DRDC Toronto is the providing Human Factors expertise to support this project. In order to develop PPE recommendations to overcome any change or increase in vulnerability a comprehensive understanding of physiological, biomechanical, task performance and operational impact of increasing coverage and/or level of protection of soldiers needs to be obtained. The objective of this study was to develop a number of operational scenarios that encompassed the majority of tasks performed by mounted crewmen and then lead a number of crews through these scenarios and identify: 1) tasks of mounted crewmen, 2) how exposed mounted crewmen are to the effects of IED blasts? and 3) the ranges of motion that are required for mounted crewmen position. Based on the availability of vehicles a total of 8 vehicles (G-Wagon, MLVW, HLVW, TLAV, Bison, Leopard C2 Tank, Coyote, and the LAV III) were used for the Behavioural Task Analysis (BTA). Each vehicle had at least one full crew of participants for a total of 28 participants.

A list of tasks typically performed by vehicle crews was developed and ranges of motion required for the performance of these tasks were determined. The level of exposure to blast threats was assessed for each crew position and compared with existing PPE. With the exception of some driver and crew commander stations, all personnel required full ranges of motion. A number of crew positions, in particular air sentries and personnel operating external machine guns were typically exposed from the waist up. These two factors, coupled with the confined spaces many crew members occupy present challenges to the design of PPE for these personnel. In general the trial participants were satisfied with the existing PPE but did express concerns over the level of coverage, in particular the side, neck, throat and pelvis. They recommended that additional coverage be investigated for the face, throat and neck, upper limbs, sides and groin. There were also concerns expressed over the design of the current shoulder caps.

Sommaire

RDDC Valcartier a pris le commandement d'une initiative d'équipement de protection individuelle (EPI) pour la lutte aux IED (C-IED) horizon 0, qui est un sous-projet d'un Programme de démonstration de technologie (PDT) de C-IED plus important. RDDC Toronto fournit les connaissances spécialisées en ergonomie pour soutenir ce projet. Afin de formuler des recommandations relativement à l'EPI pour corriger toute augmentation de la vulnérabilité, il faut obtenir une compréhension générale de l'incidence sur la physiologie, la biomécanique, le rendement de tâches et les opérations de l'augmentation de la couverture/de la protection des soldats. L'objectif de cette étude consistait à élaborer un certain nombre de scénarios opérationnels qui comprenaient la majorité des tâches accomplies par les membres d'équipage embarqués puis à soumette un certain nombre d'équipages aux scénarios et à déterminer les choses suivantes : 1) les tâches des membres d'équipage embarqués, 2) le niveau d'exposition des membres d'équipage embarqués aux effets d'explosions d'IED et 3) les amplitudes de mouvement nécessaires pour les postes d'équipage embarqué. Selon la disponibilité des véhicules, un total de 8 véhicules (G-Wagon, VLMR, VLLR, VBLC, Bison, char Leopard C2, Coyote et VBL III) ont été utilisés pour l'analyse comportementale des tâches. Chaque véhicule comptait au moins un équipage complet de participants, ce qui donne au total 28 participants.

Une liste de tâches habituellement accomplies par les équipages de véhicule fut développée et les amplitudes de mouvements requis pour l'exécution de ces tâches ont été déterminés. Le niveau d'exposition aux menaces explosives fut évalué pour chaque poste de l'équipage et comparé aux EPI existant. À l'exception de certains postes de conducteur et commandant d'équipage, tout le personnel nécessitait une pleine amplitude de mouvements. Plusieurs postes d'équipage, en particulier les sentinelles aériennes et le personnel opérant des mitrailleuses externes, étaient typiquement exposé de la taille en montant. Ces deux facteurs, joint aux espaces restreints que plusieurs membres d'équipage occupent présentent des défis pour la conception d'EPI pour ce personnel. En général, les participants de l'essai étaient satisfaits de L'EPI actuel mais ont exprimé des préoccupations concernant le niveau de protection, en particulier les côtés, le cou, la gorge et le bassin. Ils recommandent que des investigations soient faites pour de la protection supplémentaire du visage, de la gorge, du cou, des membres supérieurs, des côtés et des aines. Des préoccupations furent également formulées concernant les épaulettes actuelles.

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1 Introduction

Since the beginning of Canada's presence in Afghanistan in 2002 approximately two dozen soldiers have lost their lives due to improvised explosive devices (IEDs). Often used in unconventional warfare, IEDs pose an asymmetrical threat on today's armed forces. Many IEDs are designed to destroy, inhibit, distract, or delay personnel or vehicles. The use of IEDs has changed the pattern and probability of injury for both mounted and dismounted personnel. Current Protective Clothing and Equipment designs may not have accounted for the nature of the IED threat in the past and should be revisited. DRDC Valcartier has taken the lead on a Counter-IED (C-IED) Personal Protective Equipment (PPE) Horizon 0, which is a sub-project of a larger C-IED Technical Demonstration Project (TDP). DRDC Toronto is providing the Human Factors expertise to support this project. In order to develop PPE recommendations to overcome any change or increase in vulnerability a comprehensive understanding of physiological, biomechanical, task performance and operational impact of increasing coverage and/or level of protection of soldiers needs to be obtained. The C-IED PPE Horizon 0 addresses this issue by a series of tasks that will work to identify and address any vulnerability within the current in service PPE. These tasks include development of operational scenarios to investigate vehicle operations; conducting a task analysis of vehicle crews; conducting a state of the art review of commercial and military off the shelf options for enhancing protection of the soldier's torso, neck, nape and extremities; developing a testing protocol to investigate the trade-off between PPE coverage and level of PPE protection with soldier task performance, acceptance and comfort; and finally participation in data-mining to investigate the pattern, threat type, severity, and body locations of ballistic and blast injuries detailed in the US Combat Trauma Registry at the Naval Health Research Center in San Diego, California. This report is focused on the initial two tasks of developing operational scenarios to investigate vehicle operations and conducting a task analysis of vehicle crews.

This may be achieved through a Behavioural Task Analysis (BTA). A BTA is a decomposition of a task into a series of observable behaviours that are required to complete the task. It can be used to measure the capabilities needed to perform a specific job and identify what modifications are necessary in order to make the job more effective and efficient. A BTA was conducted for a total of 8 vehicles (based on availability) that are currently in use in Afghanistan. The vehicles that were used for this study included the G-Wagon, Medium Logistic Vehicle Wheeled (MLVW), Heavy Logistic Vehicle Wheeled (HLVW), TLAV, Bison, Coyote, Leopard C2 Tank, and the Light Armoured Vehicle (LAV) III.

This report will provide the results of the focus group that was held to develop the operational scenarios, as well as, the results of the BTA for all mounted crew positions on the available scenarios. Based on the findings of this report, gaps in the current in-service PPE will be identified and potential resolutions will be suggested.

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2 Aim

The aim of this project is to conduct a BTA for the mounted crewman in various vehicles in support of Phase I of a PPE protection versus performance trade-off analysis, as part of the C-IED TDP Horizon 0 PPE project. The objective is threefold:

1) Develop operational scenarios to investigate vehicle operations;
2) Conduct a task analysis of vehicle crew, especially those exposed crew position; and
3) Indicate the likely ballistic threats in each crew station, identifying specific crew stations and tasks that could negatively be affected by the current and additional PPE.

2.1 Abbreviations

AAR	After Action Reports
APS	Armour Protection System
BTA	Behavioural Task Analysis
C-IED	Counter- IED
CC	Crew Commander
Comms	Communications
CDA	Control Display Assembly
CER	Combat Engineer Regiment
CEU	Command Entry Unit
DRDC	Defence Research and Development Canada
HF	Human Factors
HLVW	Heavy Logistic Vehicle Wheeled
HSI®	Humansystems Inc.
IED	Improvised Explosive Device
LAV	Light Armoured Vehicle
MLVW	Medium Logistic Vehicle Wheeled
OCS	Operator Control Station
PPCLI	Princess Patricia's Canadian Light Infantry
PPE	Personal Protective Equipment
ROE	Rules of Engagement
ROM	Range of Motion
RWS	Remote Weapon System
SME	Subject Matter Expert
TACNAV	Tactical Navigation System
TDP	Technical Demonstration Project
VBIED	Vehicle Borne-IED
WWW	World Wide Web

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3 Method

3.1 Scenario Validation

A literature search was conducted to review IED and Vehicle Borne-IED (VBIED) literature including After Action Reviews (AARs). The literature described incidents where IEDs were encountered and provided little details of the situation and circumstances. Sources/databases reviewed included:

- DRDC Toronto database
- The Canadian Forces Centre of Excellence for Peace Support Operations Training
- HSI® Library
- World Wide Web (WWW)

From the convergence of these results, typical threat scenarios (five operational scenarios) were formed. A two day validation trial was conducted to validate the scenarios developed. It was undertaken at CFB Edmonton on 1 February 2007 to 2 February 2007. A total of 4 subject matter experts (SMEs) were present in the focus group. The SMEs were soldiers that have recently returned from extensive tours in Afghanistan and had operational and combat experience. SMEs included Drivers, Crew Commanders (CC) and, Air Sentries. After the two day validation trial the five operational scenarios were down-selected to four operational scenarios that according to the SMEs would involve the majority of tasks that mounted crewmen would encounter in Afghanistan. The list of operational scenarios is described in future sections, as well as, lists of tasks performed by Drivers, CC, and Air Sentries.

3.2 Behavioural Task Analysis

A BTA was conducted at CFB Edmonton from 19 – 21 March 2007 – See Figure 1. A total of 28 soldiers from Princess Patricia's Canadian Light Infantry (PPCLI), Lord Strathcona's Horse (Royal Canadian) (LdSH (RC)), Combat Engineer Regiment (1CER) and 1 Headquarters and Signals Squadron. There were a total of eight armoured vehicles evaluated with at least one full crew for each vehicle. A detailed list of the trial schedule is provided in Figure 1.

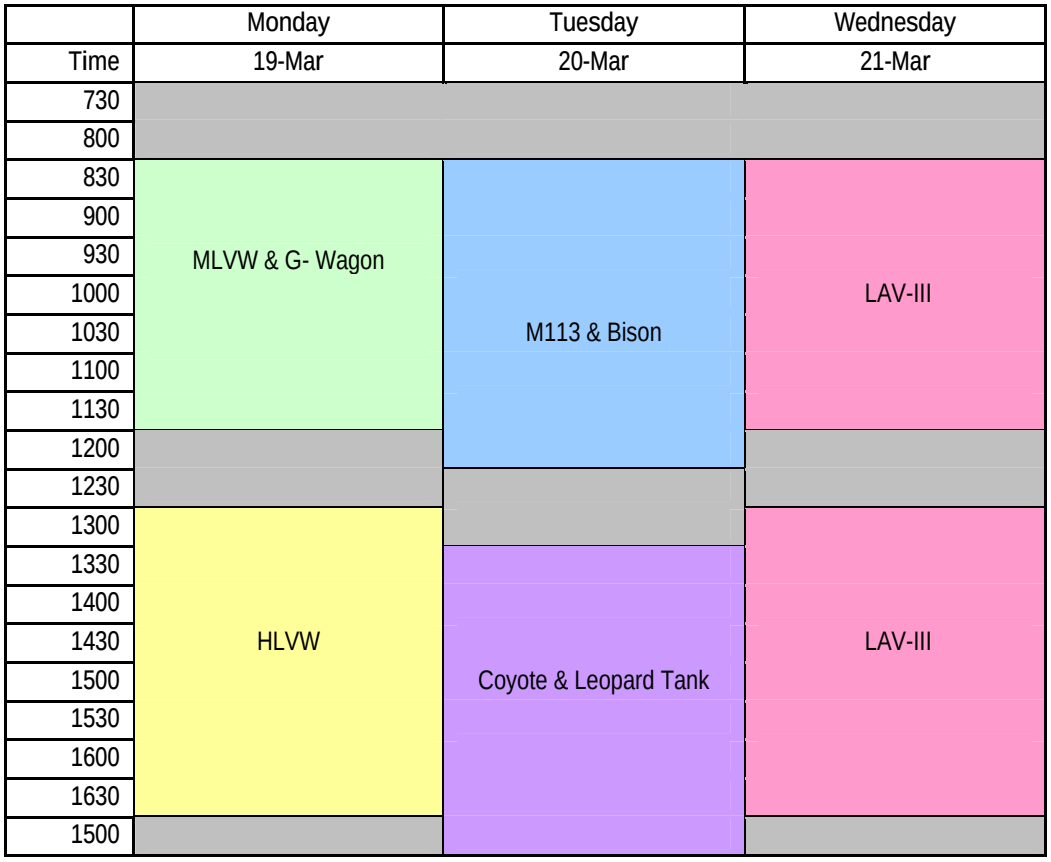

Figure 1: Trial Schedule for Behavioural Task Analysis of Mounted Crewmen

3.2.1 Trial Participants

A total of 28 soldiers from PPCLI, (LdSH (RC)), 1CER and 1 HQ & Sigs Sqn participated in the trial. The 28 soldiers consisted of 11 Drivers, 11 Crew Commanders (CCs) and Gunners, 5 Air Sentries, and 1 Loader – See Table 1. All participants had operational experience with their specific vehicles.

Table 1: List of Trial Participants by Vehicle Type and Position

	DRIVER	CC	GUNNER	AIRSENTRY	LOADER
BISON	2				
COYOTE	1	1	1		
LAV III	2	2	2	5	
G-WAGON	3				
HLVW	1				
MLVW	1				
TLAV		2	1		
LEOPARD	1	1	1		1

3.2.2 Data Collection

Each session of each day during the BTA trial began with all members of the specific vehicle crews receiving an initial briefing. The initial briefing included the methods and objectives of the trial. Once the briefing was concluded all participants completed a subject information questionnaire for general information purposes. Participants were then broken up into crews and the crews were separated and paired with Human Factors (HF) observers. Participants then gave the HF observers descriptions of the general tasks they perform while on the vehicle. HF observers then provided the participants with specific operational scenarios and then the participants provided the HF observers with descriptions of how their tasks are altered and what movements they perform. The participants performed these tasks mounted on the vehicle while the HF observer took notes, video, and pictures of the tasks being performed. All participants wore ballistic plates in their fragmentation vests during the BTA. Specific assessments such as, reach distances and trunk motion were measured during the course of the trial, as well as, problems with the current PPE during access and egress of the vehicle during normal and emergency situations. Once the HF observer led the participants through the operational scenarios and all notes, videos, and pictures were taken the participants completed a questionnaire evaluating their current in-service personal protective equipment. The questionnaire varied in the compatibility section depending on the participants' role within the crew. All questionnaires are included in Annex B.

3.2.3 Evaluation Metrics

The following metrics were taken over the course of this trial and used for evaluation purposes:

1) Reaching Distances;
2) Exposure;
3) Range of Motion of Major Joints;
4) PPE Questionnaire Results; and
5) Focus Group Results.

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4 Results

4.1 Scenario Validation

The results of the scenario validation trial included the four operational scenarios and a list of tasks that are performed by Drivers, CCs, Gunners and Air Sentries.

4.1.1 Operational Scenarios

As a result of the validation trial conducted from 1 – 2 February 2007, four operational scenarios were developed that encompassed the majority of tasks encountered by mounted crewmen in Afghanistan. A brief description of the four operational scenarios is presented below while the operational scenarios in full are presented in Annex A.

1) **Quick Reaction Force: Close Country-** This scenario involves a convoy of vehicles that has stopped for lunch when they receive a call to aid a group of dismounted infantry soldiers who have been attacked and ambushed within an urban Afghani town. The convoy of armoured vehicles get the call while they are having lunch outside of the town. The soldiers must quickly don their PPE and travel approximately 35 miles to the town. En route to the town the convoy is the target of a roadside IED.
2) **Broken Down Vehicle: Inside City Scenario-** This scenario involves a vehicle that is part of a convoy breaking down in an urban area. While the vehicle is broken down the soldiers provide an 'all around defence'. The soldiers are then encountered by a civilian that approaches the vehicle. During this scenario the broken down vehicle is towed to a safe spot.
3) **Engage Targets-** This scenario involves a single armoured vehicle that is under patrol in an urban Afghani town that is approached by a vehicle. The occupants of the approaching vehicle dismount and engage the soldiers. During the firefight the vehicle mounted weapon experiences a stoppage and the CC must switch to his personal weapon.
4) **Vehicle-Borne IED (VBIED) -** This scenario involves a convoy being approached by a vehicle. The approaching vehicle bears into the lead vehicle of the convoy and detonates upon impact. Fragments from the blast injure soldiers in trailing vehicles and the injured soldiers need to be extracted.

4.1.2 Common Tasks

The following lists of tasks are common amongst all mounted crewmen regardless of vehicle:

1) Donning PPE;
2) Doffing PPE;
3) Scanning/ Covering arcs;
4) Being extracted internally/ externally;
5) Helping to extract soldiers from vehicles;

6) Providing first aid, within vehicle, to soldiers injured by IED;
7) Providing self aid, within vehicle, after impact with IED;
8) Scanning for IEDs in highly cluttered areas (ex. Areas with increased amount of trash along the roadside);
9) Normal access/ egress;
10) Emergency access/ egress;
11) Visual scan of 5m;
12) Physical scan of 25m;
13) Long Distance Walking;
14) Securing Areas;
15) Firing in Kneeling Position;
16) Toss Smoke Grenades, Flashbangs;
17) Changing Vehicle Tires;
18) Vehicle Maintenance Tasks;
19) Securing Load;
20) Carrying Full Kit;
21) Room Search;
22) Crawling;
23) Manoeuvring through small 'Yoda' doors;
24) Combat Shooting;
25) Providing First Aid to other Soldiers;
26) Receiving First Aid from other Soldiers; and
27) Carrying Injured Soldiers Over Large Distances.

4.1.3 Common Driver Tasks

The following list of tasks is generally unique to the Drivers of the vehicles:

1) Control of vehicle (steering, braking, reaching);
2) Vehicle maintenance (operator's level only);
3) Replace tires (if away from maintenance facilities);
4) Fault diagnosis (inspections of drive train, filters, check for fluid leaks, etc.);
5) Attaching Tow Cables for Quick Tow (if applicable);
6) Securing and checking the security of loads; and
7) Performing a rolling replenishment.

4.1.4 Common CC Tasks

The following list of tasks is generally unique to the CCs of the vehicles:

1) Waving off approaching persons/ vehicles;
2) Acquiring Targets;
3) Carrying Assault Order;
4) Accessing personal weapons if MG fails;
5) Reloading weapons/ handling stoppages;
6) Reloading Mags/ other ammo;
7) Exchanging Ammo Between Soldiers; and
8) Engagement of targets using pintle mount: at extremes (¼ - ½ right/ left).

4.1.5 Common Air Sentry Tasks

The following list of tasks is generally unique to the Air Sentries of the vehicles:

1) Closing family hatches;
2) Waving off approaching persons/ vehicles;
3) Changing mags, ammo boxes for C6/ ammo for C9; and
4) Firing M72s and 40 mms/ throwing grenades.

4.2 Behavioural Task Analysis

The results of the Behavioural Task Analysis (BTA) are given below. First there is a brief description of the vehicle followed by the specific crewmen positions. Each crewmen position is divided into tasks (describes the tasks performed by the crewmen), exposure (describes how exposed they are to potential IED blasts), and Range of Motion (the range of motion required for the crewmen to perform their tasks).

4.2.1 G-Wagon - Light Utility Vehicle Wheeled (LUVW)

The G-Wagon is a four passenger light utility vehicle that is used by operationally tasked field units and training establishments to provide tactical transport in the fields of command and control, liaison, reconnaissance, and military police – See Figure 2. In operational theatres the G-Wagon is used with an Armour Protection System (APS), additionally the G-Wagon can be fitted with gun shields. Please note the G-Wagon used in this trial did not have the APS attached, nor did it have gun shields.

Figure 2: G-Wagon (Light Utility Vehicle)

4.2.1.1 G-Wagon Driver

4.2.1.1.1 Tasks

The Driver tasks are typical light utility vehicle tasks. The primary task of the Driver of the G-Wagon is to maintain driving control and first-line maintenance of the vehicle in all conditions. The G-Wagon Driver also performs many other tasks. Representative tasks performed are described below:

1) **Donning PPE-** This involves the Driver donning their tactical vest, fragmentation vest and their helmet before they access their vehicle. This typically takes approximately 30 seconds.

2) **Normal Access/ Egress-** The Driver must hold onto the steering wheel to lift himself up into the vehicle – See Figure 3.

Figure 3: (Left) G-Wagon Driver's Side (Right) G-Wagon Normal Access

The Driver usually keeps their weapon within his reach. As seen in Figure 4, the Driver kept his rifle between the door and his seat. It is within an arm's reach.

Figure 4: G-Wagon Driver Weapon Storage

3) **Normal Driving**- This task involves the Driver having both hands on the wheel at the 9 o'clock and 3 o'clock positions. The Driver will rarely leave the wheel to do another task. While driving, the participants reported that they always wear ballistic goggles and helmets.

4) **Scanning for IEDs in highly cluttered areas**- The participants reported that this was a combined effort between the CC and the Driver. Driving in the city versus driving in the country does not change the Driver's tasks.

5) **Visual scan**- There are no designated viewing arcs, therefore both the Driver and CC must scan equally. For scanning high sides, they look straight ahead and slightly tilt their heads up. They commented that neck guards will not do anything for them because they would rather have the ROM without the neck guard constricting their movement.

6) **Physical scan of 25m**- The Driver will participate in this physical scan if he is needed. Usually in a convoy, he will not need to participate in this because there will be a sufficient amount of soldiers to do so.

4.2.1.1.2 Exposure

If the G-Wagon is not fully armoured the Driver experiences complete exposure (less the protection provided by inherent vehicle structures). Driver's upper arms are exposed as well as his face and neck.

Even if the G-Wagon has the APS attached, the vehicle is still lightly armoured. The APS is only required to defeat small mines (up to 1 Kg), small arms fire and artillery and mortar fragments. If the G-Wagon is fully armoured, then there is no exposure for the Driver. Even when halted, the Driver will very rarely open his door and shoot out of it. The participants reported that this is very uncommon and almost never happens.

In the scenarios where another vehicle in the convoy breaks down, the Driver of the G-Wagon will not get out of the vehicle. He will let the passenger or soldiers in the other vehicles get out and tend to the situation and provide security. In the scenarios of own vehicle breakdowns, the Driver will get out and perform a visual inspection of the drive-train, search for fluid leaks, check filters etc. He is then fully exposed.

4.2.1.1.3 Range of Motion

The ROM for a G-Wagon Driver is not extreme. The most extreme reach is with the right arm and it is approximately 90cm. The normal reach for the Driver is approximately 64cm (see Figure 5) to reach the controls or stick shift.

Figure 5: (right) Normal Reach of G-Wagon Driver, (left) Extreme Reach

The Driver will rarely reach over to the CC's side. The only occasion when this might occur is to use the communications system, however, this would only occur if for some reason the CC was unable to do so himself.

Neck extension and rotation are important to the Driver while performing his driving task and scanning/ visual search tasks. The Driver requires less than 30° of neck flexion and approximately 180° of neck rotation.

4.2.1.2 G-Wagon Gunner

Please note that the G-Wagon utilized in the BTA was not equipped with a gun shield or a roof hatch. It should be noted that G-Wagon's are originally deployed without a gun shield – see Figure 6. The following results for the G-Wagon Gunner are based upon a combination of combat experience and an expert review of similar hatch gunner tasks.

Figure 6: Early G-Wagon Hatch Gunner Station with Ring Mount

4.2.1.2.1 Tasks

The primary task of the Gunner of the G-Wagon is to conduct visual scanning for threats and IEDs. The Gunner is also responsible for the operation of vehicle mounted weapon. The G-Wagon Gunner also performs many other tasks. Representative tasks performed are described below:

1) **Donning PPE-** This involves the gunner donning their tactical vest, fragmentation vest and their helmet before they access their vehicle. This typically takes other crew approximately 30 seconds. Given the small hatch space it is believed that hatch Gunner's may not typically wear their tactical vest.

2) **Normal Access/ Egress-** The hatch gunner accesses the gunner position from the rear cab of the G-Wagon. Once inside the vehicle they must pull themselves up into the hatch. The Gunner can stand on the vehicle floor or he can use a webbing strap to sit on.

3) **Scanning for IEDs in highly cluttered areas**- While driving in highly cluttered areas the Gunner provides support to the Driver and CC by scanning for IEDs. The participants reported that this was a combined effort by the crew. Driving in the city versus driving in the country does not change the gunner's tasks. G-Wagon's deployed with a gun shield may impair the Gunner's field of view. However, the gun shield includes transparent armour to improve the Gunner's field of view – See Figure 7.

4) **Visual scan**- Hatch gunners are typically given a designated scanning arc in a convoy or on the move. Similar to the scanning for IEDs the gun shield may impair the field of view but it does come equipped with transparent armour to aid the problem.

5) **Engage Targets** –Hatch Gunners can engage targets with the ring-mounted C6 and their personal weapon. The Gunner usually keeps their personal weapon inside the vehicle within reach. The weapon station includes side armour, back armour (hatch door) and front armour (gun shield). The hatch gun can be rotated 360 degrees. The ability of the hatch Gunner to engage close-in targets is unknown due to the unavailability of a G-wagon with a hatch shield.

6) **Physical scan of 25m**- The gunner will typically never dismount the G-Wagon.

7) **Rotating Turret**- In order for the hatch Gunner to rotate the turret they must use their hand to manually turn the control – See Figure 9.

Figure 7: G-Wagon Hatch Gunner with Ring Mounted C6

Figure 8: Gunner's Hatch with Gun Shield

4.2.1.2.2 Exposure

A review of G-Wagon hatch gunner photos reveals that for the majority of the hatch Gunners tasks they are exposed from the waist up. Therefore, the entire upper body including the head and face are exposed. G-Wagons that are not equipped with a gun shield leave the hatch Gunner more exposed. The Gun shield does provide added protection to the Gunner. From the sides the Gunner remains exposed from the shoulders up leaving the head, face, and neck exposed. From the front and rear it appears that the Gunner's upper body and neck are protected leaving the majority of their face and head exposed.

4.2.1.2.3 Range of Motion

The ROM for a G-Wagon Gunner is not extreme. Their most extreme ROM involves the shoulder and elbow when engaging targets with the vehicle mounted weapon. This requires minimal amounts of shoulder flexion with approximately 90º of elbow flexion. The Gunner is also required to bend at the waist and extend their arm to reach down and access their personal weapon. Neck extension and rotation is important to the Gunner while performing their scanning/ visual search tasks. The Gunner requires less than 30° of neck flexion and approximately 180° of neck rotation.

Figure 9: G-Wagon Hatch Gunner Manually Controlling the Turret

4.2.1.3 G-Wagon Crew Commander

4.2.1.3.1 Tasks

The primary task of the CC of the G-Wagon is to conduct visual scanning and man the communications (radios, etc). All CC tasks are described below:

1) **Donning PPE-** This involves the CC donning their tactical vest, fragmentation vest and their helmet before they access their vehicle. This typically takes approximately 30 seconds.

2) **Normal Access/ Egress-** The CC must hop into the vehicle as there is nowhere to hold to get into the passenger side of the G-Wagon. The height of the cab is approximately 60 cm and it is not that much trouble to access.

   The CC usually keeps their weapon within his reach. Participants reported that they either hold it or keep it between the door and their seat. They try to avoid having the weapon facing up in case it accidentally fires.

3) **Scanning for IEDs in highly cluttered areas-** This is a combined effort between the CC and the Driver. The CC will pay particular attention to high sides.

4) **Visual scan-** There are no designated viewing arcs, therefore both the Driver and CC must scan.

5) **Physical scan of 25m-** If there is any suspicion of mines; the CC will prod out 1m with a stick or knife to detect them. He will do so, and then carefully step on safe ground.

4.2.1.3.2 Exposure

Identical to the Driver, if the G-Wagon is not fully armoured the CC experiences some exposure. His upper arms are exposed as well as his face and neck. If the G-Wagon is armoured the CC is not exposed through the windows as they provide ballistic and flash protection.

If the G-Wagon is fully armoured, then there is no exposure for the CC in the G-Wagon. This vehicle is fully enclosed. The CC will very rarely open his door and shoot out of it. As G-Wagons are used mostly in the wire, or only in a convoy, the convoy will provide security support mitigating the need for the CC to be exposed.

In the scenarios where another vehicle in the convoy breaks down, the CC of the G-Wagon will get out of the vehicle to attend to the situation (if maintenance) and provide security. In the scenarios of vehicle maintenance or tire change, the CC must get out and assist, and he experiences full body exposure.

4.2.1.3.3 Range of Motion

The CC consistently monitors the comms. His position is directly towards the radios/comms, so there is less than 90° shoulder flexion and rare shoulder abduction or adduction. The typical tasks conducted by the CC do not require extreme ranges of motion. The participants reported that the collar on their fragmentation vest causes some discomfort and somewhat restricts their range of motion. This commonly occurs when they are wearing the radio headset. As seen in Figure 10, soldiers fold down their collar such that it does not interfere with their headset. This means their neck is now more exposed where the collar would normally be protecting it.

Figure 10: (Right) Folded Collar, (Left) Unfolded Collar

Neck extension and rotation is important to the CC while performing their tasks and scanning/ visual search tasks. The CC requires less than 30° of neck flexion and approximately 180° of neck rotation.

4.2.2 Medium Logistic Vehicle Wheeled (MLVW)

The Medium Logistic Vehicle Wheeled (MLVW) is part of the Army's logistic support fleet. They are used in such roles as command and control, transportation of troops and supplies, and gun towing. The MLVW has the ability of carrying a Driver and a passenger, as well as troops in the rear– See Figure 11. According to the trial participants only a few MLVWs are currently deployed in Afghanistan and are used strictly within camp confines.

Figure 11: Medium Logistic Vehicle Wheeled (MLVW)

MLVWs deployed to Kabul in 2003/04 utilized a protective armour kit that consisted of four ballistic blankets (covering the floor and seats), a bullet-proof windshield, ballistic windows/kevlar plate for the upper door, as well as add-on armour plate for the lower door portion and for the upper part of the rear of the cab. The MLVW utilized in this trial did not possess the add-on armour package.

4.2.2.1 MLVW Driver

4.2.2.1.1 Tasks

The main task of the Driver of the MLVW is to maintain driving control of the vehicle in all conditions and perform general maintenance duties. Above and beyond normal driving and maintenance, the Driver performs many other minor tasks that are necessary for the operation of the MLVW. Drivers typically do not dismount if the convoy has to stop for an IED incident or small arms ambush.

1) **Donning PPE-** This involves the Driver donning their tactical vest, fragmentation vest and their helmet before they access their vehicle. This takes approximately 30 seconds. It should be noted that shorter Drivers may have to have their seat fully forward to reach the pedals and controls and as a result the tactical vest interferes with the steering wheel.

2) **Normal Access/ Egress-** This task involves the Driver climbing from the ground into the cab of the MLVW by using a number of footholds. Normal egress involves the same footholds just used in the inverse order. The Driver also needs to access the hood of the MLVW to perform general maintenance and repair duties – See Figure 12. All the Drivers reported removing their fragmentation vest shoulder caps because they got caught mounting and dismounting the vehicle.

Figure 12: Driver Accessing Hood of MLVW

3) **Normal Driving-** This task involves the Driver having both hands on the wheel at the 10 o'clock and 2 o'clock positions. When the Driver needs to turn the MLVW one hand needs to be placed on the wheel at the 12 o'clock position – See Figure 13. One Driver reported that his fragmentation vest shoulder pads interfered with his ability to drive.

Figure 13: MLVW Driver in Normal Driving Position

4) **Reaching Controls-** There are a number of controls that the Driver must reach for during normal operation of the vehicle. These controls include: High beams, differential locks, etc. and these controls range in distance from 53 – 63 cm.

5) **Loading/ Unloading Cargo-** The Driver of the MLVW is also responsible for loading, unloading and securing the cargo in the back of the truck. The Driver needs to place their hand in the back, on the deck of the cargo space, and then place foot in foot foothold and then swing the opposite leg into the back of the truck – See Figure 14.

Figure 14: Driver Accessing and Egressing from Rear of MLVW

6) **Accessing C7 Weapon- -** The Driver will have to reach behind themselves with their right arm to access their C7. Some Drivers chose not to keep their C7 in the rifle rack but instead keep along side the door or alongside them on their right. While this makes

the rifle more easily accessible – See Figure 15, anything not secured in the cab gets jostled around when driving off paved roads.

Figure 15: Placement of C7 When Driving MLVW

7) **Vehicle Breakdown**- The Driver is responsible for the general maintenance of the MLVW and if they experience problems outside the wire the Driver will attempt to diagnose the problem and if he believes he can fix it he will attempt to e.g. changing tire – See Figure 16. Drivers do report removing their tactical vests if they have to crawl underneath their vehicle.

Figure 16: MLVW Performing Tire Change

MLVW's are usually recovered by a wrecker using an A-frame tow bar.

8) **Prodding for Mines-** For the majority of the time the Driver will stay inside the vehicle but if the vehicle crew believes they are inside a minefield, the Driver may have to extract himself and his vehicle. This will require a Driver to prod the ground before stepping out. A clear zone will be marked first where feet can be planted and then a 1 metre wide area will be marked and the Driver will move by prodding 1 metre at a time – See Figure 17.

Figure 17: MLVW Driver Prodding for Mines

9) **Vehicle Inspection-** Prior to leaving the wire or during breaks the Driver is responsible for general maintenance checks on the vehicle. This involves the visual inspection of the running gear, tires and engine. Inspections include, checking fluids, filters, hub temperatures, etc. – See Figure 18 and Figure 19.

Figure 18: MLVW Driver Mounting Hood

Figure 19: MLVW Driver Performing Engine Inspection

10) **Accessing Fire Extinguisher-** A common scenario in IED incidents is dealing with vehicle fires. If there is a need for the Driver to put out a fire then the Driver will need to access the MLVW's fire extinguisher. The extinguisher is easily accessed on the firewall at the passenger's feet.

4.2.2.1.2 Exposure

If the vehicle does not have the added armoured package, the MLVW is fully exposed to an IED blast. As of now the MLVW is not used outside the wire but in the future it may be and this places a considerable risk to the Drivers. Also, when the Drivers are performing duties outside an armoured vehicle they are fully exposed to all IED blasts.

4.2.2.1.3 Range of Motion

To perform all their duties the Driver of the MLVW needs full range of motion of both their shoulders. The most extreme shoulder postures are around 70º of shoulder flexion while the Driver accesses the hood, cab, and the back for loading and unloading cargo. The Driver also requires upwards of 60º of shoulder abduction while they prod the ground for landmines and reach to the various controls within the MLVW. They also require full range of elbow motion when they reach for the vehicle controls and access the cab, hood, and rear of the MLVW. The Driver also needs 90º or greater hip and knee flexion (depending on height of Driver) when they climb into the cab, onto the hood, and into the rear using the footholds. The Driver also requires up to 90º of trunk flexion to bend over the hood and perform general vehicle maintenance duties.

4.2.3 Heavy Logistic Vehicle Wheeled (HLVW)

The Heavy Logistic Vehicle Wheeled (HLVW) provides the Army with a heavy lift support capability. It is used during missions of territorial defence, domestic emergencies, combat support, and peacekeeping. The HLVW has the ability of carrying a Driver and a passenger, as well as, an

Air Sentry and rear passengers – See Figure 20. It should be noted that HLVW's deployed in Afghanistan have air conditioners mounted on top of the vehicle cab eliminating the possibility of having an air sentry.

Figure 20: Heavy Logistic Vehicle Wheeled (HLVW)

4.2.3.1 HLVW Driver

4.2.3.1.1 Tasks

The main task of the Driver of the HLVW is to maintain driving control of the vehicle in all conditions. Above and beyond normal driving, the Driver performs many other minor tasks that are necessary for the operation of the HLVW.

8) **Donning PPE-** This involves the Driver donning their tactical vest, fragmentation vest and their helmet before they access their vehicle. This takes approximately 30 seconds. Participants reported that they did not wear their tactical vest when driving as it interfered with the steering wheel when the vest was combat loaded – see Figure 21. It should be noted that while some HLVW Drivers do not wear their tactical vest when operating the vehicle, the participants reported that their co-drivers always wore their tactical vest in case they had to dismount.

Figure 21: Tactical Vest Interference with Steering Wheel

9) **Normal Access/ Egress-** This task involves the Driver climbing from the ground into the cab of the HLVW by using a number of footholds. The 1st foothold is approximately 71 cm from the ground while the 2nd foothold is approximately 107 cm from the ground and finally the final foothold into the cab of the HLVW is approximately 142 cm. Normal egress involves the same footholds just used in the inverse order.

10) **Adjust Seat Controls-** Once the Driver has accessed the cab of the HLVW they must adjust the controls of the seat so that the seat is in a comfortable position. Since, the controls are on the side of the seat the Driver must laterally bend the trunk and abduct the arm to reach them.

11) **Normal Driving-** This task involves the Driver having both hands on the wheel at the 9 o'clock and 3 o'clock positions. When the Driver needs to turn the HLVW one hand needs to be placed on the wheel at the 12 o'clock position which was approximately 79 cm from the sternal notch of our SME – See Figure 25.

12) **Reaching Controls-** There are a number of controls for which the Driver must reach during normal operation of the vehicle. These controls include: High beams which are approximately 76 cm from the seated Drivers right shoulder, differential locks which are approximately 81 cm from the seated Drivers right shoulder, reach above head to access the interior light, and the furthest control option which is approximately 84 cm from the seated Drivers right shoulder – See Figure 26.

13) **Loading/ Unloading Cargo-** The Driver of the HLVW is also responsible for loading and unloading the cargo in the back of the truck. The Driver needs to reach above shoulder height into the back of the HLVW to access a ramp. The ramp is then pulled out and attached to the back of the HLVW where it is used by the Driver to walk up to and walk down from the back of the HLVW – See Figure 27. Some HLVWs come equipped with footholds that the Driver can use to access the rear – See Figure 22.

Figure 22: HLVW Climbing into Rear

14) **Securing Cargo-** The Driver is also responsible for climbing onto the back of the HLVW to tie down and secure any cargo. Most Drivers access the cargo area from the vehicle cab and over the HIAB crane- see Figure 23.

Figure 23: Driver Moving to Secure Load from Can Compartment

15) **Accessing C7 Weapon-** The Driver will have to reach behind them with their right arm to access their C7 – See Figure 24.

Figure 24: HLVW Driver Reaching Back to Access C7 Rifle

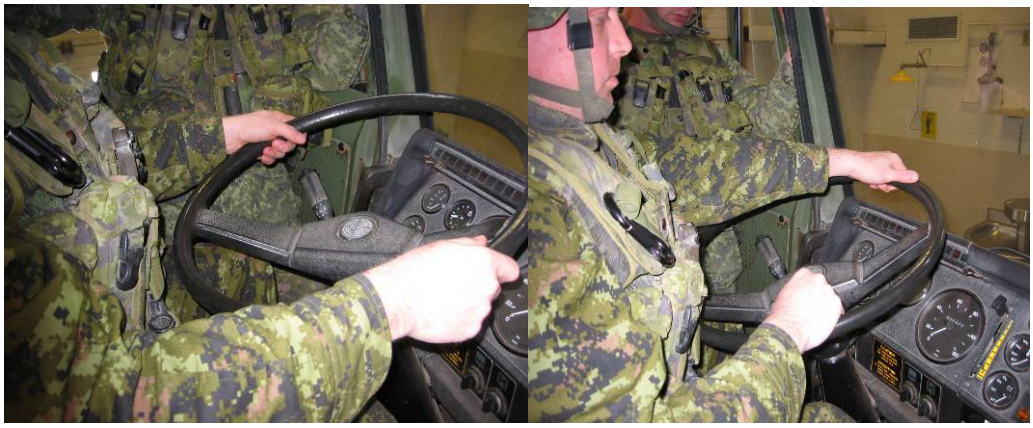

Figure 25: a) HLVW Driver Hand Positions during Normal Driving Conditions, b) HLVW Driver Hand Positions While Turning

Figure 26: a) HLVW Driver Reaching High Beams Control, b) HLVW Driver Reaching Differential Locks, c) HLVW Driver Reaching Furthest Possible, d) HLVW Driver Reaching Interior Light

Figure 27: HLVW Driver Accessing Ramp Needed to Load and Unload Cargo

4.2.3.1.2 Exposure

If the vehicle does not have the added armoured package, the HLVW is fully exposed to an IED blast. HLVWs operating outside the wire are currently equipped with an added armoured package consisting of strapped on steel plates and ballistic glass inserts. It should be noted that the add-on armour reduces a driver's forward and side visibility. Figure 28 shows a Driver demonstrating of the vertical field of view when the steel inserts

are strapped on. Please note that ballistic glass is also added to the windscreen. When the Drivers are performing duties outside the vehicle they are fully exposed to all IED blasts.

Figure 28: Portion of window available for exterior viewing when the armour package is mounted on the HLVW.

4.2.3.1.3 Range of Motion

To perform all their duties the Driver of the HLVW needs full range of motion of both their shoulders. The most extreme shoulder postures are greater than 90º of shoulder flexion while the Driver accesses the ramp in the back for loading and unloading cargo. The Driver also requires upwards of 60º of shoulder abduction when they access the control within the vehicle. They also require full range of elbow motion when they reach for the vehicle controls and access the cab of the HLVW. The Driver also needs 90º or greater hip and knee flexion (depending on height of Driver) when they climb into the cab using the footholds, as well as, when they climb into the back of the HLVW using the fold down step ladder.

4.2.4 Tracked Light Armoured Vehicle (TLAV)

The TLAV is an upgraded Armoured Personnel Carrier (M113 APC) that was primarily used as a mechanized infantry section carrier. The TLAV upgrade includes new engines, transmissions and drive trains; the provision of add-on armour; and the stretching of 147 vehicles to increase their capacity and mobility. At the time of this report the TLAV was being used as combat support and combat service support vehicle for the Army. Reports in the current press suggest that TLAVs may be replacing some LAV III vehicles due to battlefield attrition and scheduled depot repairs. The M113A3 is a tracked vehicle capable of extended cross-country travel over rough terrain, and high speed operation on improved roads – See Figure 30.

TLAVs can be equipped with a one-person Cadillac-Gage turret -see Figure 29, a Protected Weapons Station (PWS) – See Figure 30 or a pintle-mounted machinegun.

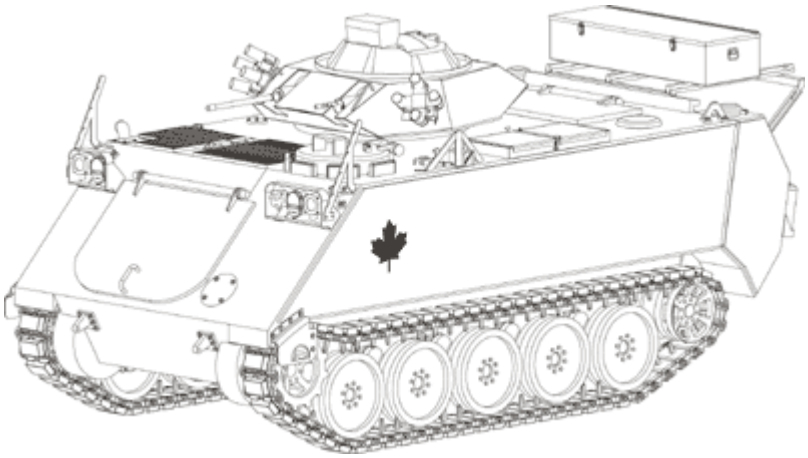

Figure 29: M113A3

Depending on the mission and TLAV variant, the TLAV crew could include Air Sentries. The TLAV available for this investigation was the Mobile Tactical Vehicle Recovery (MTVR) variant used by mechanics. The MTVR variant only has Driver and CC positions.

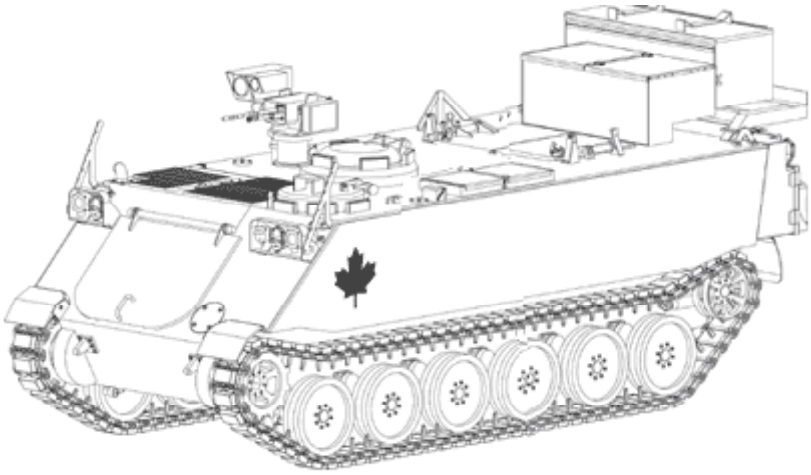

Figure 30: Mobile Tactical Vehicle Recovery (MTVR) TLAV Variant

4.2.4.1 TLAV Driver

4.2.4.1.1 Tasks

The main task of the Driver of the TLAV is to maintain driving control of the vehicle in all conditions. All Driver tasks are described below:

1) **Donning PPE-** This involves the Driver donning their tactical vest, fragmentation vest and their helmet before they access their vehicle. This takes approximately 30 seconds.

2) **Driving-** The Driver is responsible for complete control of the TLAV as it pertains to movement and steering. The Driver normally stores his gear and weapon to his left

hand side. They typically do not use their weapon as it is not part of their routine tasks.

3) **Normal Access and Egress-** The Driver has to access the Driver's station via his hatch. The participants reported that the size of the hatch will not fit all Drivers (i.e. it is too small). Drivers usually have to lift their hands up over their head to get in. To get out they must lift themselves out by propping their arms against the hatch rim (see Figure 31).

Figure 31: TLAV Egress

4.2.4.1.2 Exposure

The exposure of the TLAV Driver is situationally dependent, due to restrictions in field of view through their episcopes; Drivers will operate in a hatches-up position when possible. While in a convoy in urban or rural terrain, the Driver usually operates with only the top half of their head exposed. Drivers adjust their seats so they can just see over their centre episcope. As seen in Figure 32 left, this position results in minimal exposure. However, this position does not provide vehicle protection to the cranium. If the convoy is travelling in a "safe" area in the countryside, the Driver may drive with more of his head exposed (see Figure 32 right). Figure 33 shows the TLAV Driver exposure with hatches up from the side; in this position the shoulders, neck, and face are fully exposed. Many Drivers do not wear their shoulder pads because they have a difficult time fitting into the hatch. Wearing their shoulder pads in this position may provide protection from horizontal or overhead blasts.

Figure 32: TLAV Driver Exposure- High Risk (left) and in Countryside (right)

Figure 33: TLAV Driver Typical Exposure in Countryside

If it is known that the convoy is in an "unsafe" area, or during an ambush the Driver will drive hatches down. Once the Driver is down with the hatch closed, he experiences no direct exposure.

4.2.4.1.3 Range of Motion

The participants reported that the hatch size may not be sufficient for some larger Drivers. Some may get wedged in – See Figure 34. They also reported that their shoulder pads interfere; therefore they rarely wear them while driving.

Figure 34: TLAV Driver Wedged in Hatch

In the hatch, the Driver can easily access his driving controls. Except for mounting the vehicle there are no extreme ranges of motion required by the Driver. The Driver needs 90º or greater hip and knee flexion (depending on height of Driver) when they climb into the TLAV using the footholds on the side of the TLAV. The Driver also needs full shoulder ranges of motion when dropping down into the hatch. While driving most of the motion is done with the arms (steering) and with the neck (moving head for scanning/viewing).

4.2.4.2 TLAV Crew Commander

4.2.4.2.1 Tasks

The vehicle CC is typically an officer or Non-commissioned officer (NCO) and is responsible for the control and coordination of the vehicle and the crew. The CC keeps constant lookout for evidence of IEDs, the enemy, observes the zone for which he is responsible, and attends for any orders from the convoy commander's vehicle. In action, the CC gives his orders to the Driver by radio intercom. If required the CC engages targets using his vehicles weapon systems. A detailed list of tasks performed by the CC is given below;

1) **Donning PPE-** This involves the CC donning their tactical vest, fragmentation vest and their helmet before they access their vehicle. This takes approximately 30 seconds. While smaller personnel can squeeze through hatches wearing the fragmentation vest and tactical vest, the majority cannot. Most CC reported that they did not wear the tactical vest.

2) **Viewing/ Scanning-** The CC usually stands on the seat of the CCs station when scanning and viewing for IEDs or VBIEDs. When scanning high sides the CC looks upwards both in the forward and side directions – See Figure 35. The CC may also

stand on their toes to look over the side of the TLAV at trash and garbage on the side of the road. This depends on the height of the CC.

Figure 35: CC of the TLAV Viewing High Sides

3) **Securing Antenna-** When travelling under a low level ceiling the CC needs to reach behind him and pull down the antenna so it does not contact the ceiling and break off – See Figure 36.

Figure 36: TLAV CC Reaching Behind to Secure Antenna

4) **Crouching-** If the threat level increases the CC will crouch down into the hatch with his feet remaining on the seat and his knee joint fully flexed, leaving only the top of his helmet exposed – See Figure 37.

Figure 37: TLAV CC Crouching into Hatch

5) **Engage Targets** –Depending on the TLAV/M113A3 variant, the CC can engage targets with a variety of weapon systems such as their personal weapon, the PWS or a pintle-mounted machinegun. While the PWS is designed to be controlled from inside the TLAV, it can be operated at the weapon station manually if there is a firing circuit failure. In order to manually operate the PWS C6, the CC has to expose himself from the waist up. The height of the handles of the C6 (in the PWS) from the top of the hatch is approximately 53 cm. For TLAVs without a PWS or turret, the CC can utilize a pintle mounted machinegun to engage targets from the front, side, and rear - see Figure 38b. As with manually engaging targets with the PWS C6, CCs using the pintle-mounted C6 with a butt assembly are exposed from the waist up.

Figure 38: a) TLAV CC Engaging Targets from Side with PWS, b) TLAV CC Engaging Targets from the Front with Pintle-Mounted C6

6) **Engage Targets with pintle-mounted C6 with spade grips-** The C6 machinegun can come equipped with a butt assembly, a back plate or a spade grip assembly. The butt assembly is used for dismounted operations, the back plate is used inside a vehicle turret and the spade assembly is used when the gun is mounted on vehicles or in a tripod configuration. Participants reported that it is easier for them to control the C6 when they have spade grips. Spade grips also allow CC to have less exposure, because they can aim the weapon without having to shoulder the weapon (see Figure 39). Many CC question the viability of using pintle-mounted C6s without spade grips, for them the CC is too exposed to use the C6 safely with a regular butt assembly.

CCs expressed concern with the design of the C6 pintle machinegun mounts for current operations. They believe that these mounts were primarily designed to utilize the C6 in an anti-aircraft role and for a lesser extent, the long range engagement of ground targets. The CC stated that the current pintle mounts were not suitable for the engagement of the close-in targets found in current operations (i.e. as close as 25m). A number of CC recommended modifications to the pintle mount to lower the height of the mounted C6.

Figure 39: TLAV CC Demonstrating Arm Position When Using Spade Grips

7) **Engage Targets with Personal Weapon-** If enemies approach to a vicinity that the CC is unable to use the vehicle mounted weapons they must switch to their personal weapon (likely the C7 rifle) – See Figure 40. CC reported that Rules of Engagement (ROE) may limit the use of machineguns in cities and towns (i.e. limit collateral damage to a non-combatant population). As a result CCs are routinely forced to use personal weapons for defence.

Figure 40: TLAV CC Engaging Targets with C7

8) **Changing Ammunition -** If the CC runs out of ammunition in their personal weapon they must change the magazine while exposed out of the hatch – See Figure 41. As well, CCs are also exposed when they need to reload the C6 machinegun in the PWS and pintle mount. CC reported stowing C6 ammunition on the outside of their vehicle and thus being exposed when they reach over or down to grab boxes of linked ammunition.

Figure 41: TLAV CC Changing C7 Magazine

9) **Engage Targets with PWS (remotely) -** If the threat of attack is high or if there is a firefight taking place, the CC will move into the hatch and sit in the seat in the CC's station and control the PWS with the joystick and controls rather than manually – See Figure 42.

Figure 42: TLAV CC Operating PWS Remotely

10) **Unjamming Ammunition in PWS-** Occasionally, the ammunition that is fed into the PWS becomes jammed. The CCs responsibility is to free up the jam and ensure the safe operation of the weapon. If this is not possible the CC will switch to his personal weapon until the PWS can be fixed – See Figure 43.

Figure 43: TLAV CC Working to Repair a Jammed C6 in the PWS

11) **Moving Into and Out Of the Hatch-** The severity of the threat dictates whether the CC is standing up or sitting down in the hatch. Therefore, the CC needs to move freely between positions – See Figure 44.

Figure 44: CC Beginning to Move Out of the Hatch

4.2.4.2.2 Exposure

For the majority of tasks performed, CC's typically stand on their seat exposing approximately the top half of their body. These tasks include viewing and scanning, engaging targets with PWS and C6, and repairing the PWS. When the CC secures the antenna when travelling under a low level ceiling they are at least waist high out of the hatch and with an outstretched arm in order to reach the antenna. When travelling through an area of increased threat the CC crouches down in the hatch leaving only the top of the helmet exposed with the rest of their body in between the top of the hatch and the seat. The proximity of incoming enemies will dictate how exposed the CC is when firing their C7. The further the enemy is the lower the CC can be inside the hatch and the closer the enemy gets the higher the CC needs to be to gain a better vantage point. The range of exposure for engaging targets with the C7 or C6 can range from chin high to waist high above the hatch (see Figure 45).

Figure 45: TLAV CC Exposure Firing C6

If there is a need to clear the C6 the CC needs to be high enough to reach the weapon, exposing at least from the waist up (see Figure 46). This leaves him very exposed. Note that his upper arm motion is parallel to the ground. Another instance where the CC needs to be high is when he is engaging targets over the back deck, where he could potentially be exposed from the hips up (see Figure 47).

Figure 46: TLAV CC Exposure when Clearing Weapon

Figure 47: TLAV CC Shooting Over Back Deck

Figure 48 shows a TLAV CC demonstrating normal exposure. His arms are at the level of the hatch ring.

Figure 48: TLAV CC Normal Exposure

When egressing from the hatch, the CC arms are exposed in addition to his upper torso, shoulders, face, and neck (see Figure 49).

Figure 49: TLAV Exposure in Egress

4.2.4.2.3 Range of Motion

The CC needs full range of motion of most for the major joints. Due to the fact that the CC performs tasks where his shoulder is flexed to at least 90º and abducted to at least 90º while repairing the PWS manually. The CC also requires flexion of the elbow close to 180º to perform the repairs on the PWS, as well as, climbing out of and into the hatch. The CC also requires full knee flexion and extension range for climbing into and out of the hatch, and additional full range of hip flexion when the CC is crouching down in the hatch when travelling through an area of increased threat. The CC also requires several degrees of trunk rotation and flexion while leaning over the side of the TLAV to engage targets with their C7, as well as, rotating the PWS manually to engage targets at the side and rear of the TLAV.

4.2.5 Bison - Wheeled Light Armoured Vehicle (WLAV)

The Bison WLAV is an eight-wheeled armoured vehicle originally designed as an infantry section carrier. They are now being used as combat support variants (ambulance, electronic warfare, mobile repair team, maintenance and recovery, and NBC reconnaissance) – See Figure 50. Depending on the mission and variant the Bison crew could include Air Sentries. The Bison that was available to use was an Armoured Recovery Vehicle (ARV) variant used by mechanics. The ARV variant used on this trial only had accessible Driver and CC positions.

Figure 50: Bison WLAV

The Bison's operating in Afghanistan are currently equipped with add-on armoured packages consisting of bolt on armour plates. It should be noted that Driver's reported that the Bison's add-on armour significantly reduces a Driver's vision through the forward episcope. The Bison variant used in this trial was not equipped with the add-on armour package.

4.2.5.1 Bison Driver

4.2.5.1.1 Tasks

The main task of the Driver of the Bison is to maintain driving control of the vehicle in all conditions and perform general maintenance duties. Above and beyond normal driving and maintenance, the Driver performs many other minor tasks that are necessary for the operation of the Bison.

1) **Donning PPE-** This involves the Driver donning their tactical vest, fragmentation vest and their helmet before they access their vehicle. This takes approximately 30 seconds. The Bison Drivers noted that the tactical vest interferes with getting in and out of the vehicle. Drivers routinely do not wear the tactical vest but stow it behind their seat or place it at their side.
2) **Driving-** The Driver is responsible for complete control of the Bison as it pertains to movement and steering. Driving control of the Bison includes – steering, acceleration, deceleration, and control buttons – See Figure 51.

Figure 51: Bison Driver in Normal Driving Position, a) Front and b) Side

3) **Moving Into and Out of the Hatch-** To access the Driver's control station the Driver climbs onto the Bison from the front or side and drops down into the hatch – See Figure 52.

4) **Vehicle Maintenance-** The Driver is responsible for the general maintenance of the Bison and if they experience problems outside the wire the Driver will attempt to diagnose the problem and if he believes he can fix it he will attempt to.

Figure 52: Bison Driver Getting into the Drivers Station

4.2.5.1.2 Exposure

During typical driving tasks the Driver is exposed from their chin up leaving their head susceptible to the effects of IED blasts. If the Bison comes under small arms fire the Driver can drop to a hatches down position. As mentioned earlier, visibility for the Driver through the forward episcope is limited. If the Bison becomes disabled then the Driver

must dismount in an attempt to diagnose and fix the problem. In these instances the Driver is completely exposed to the effects of an IED blast.

4.2.5.1.3 Range of Motion

The Driver of the Bison requires full range of hip, knee, and shoulder motion for mounting and dismounting the Bison, and getting into the Drivers station. Once seated in the Driver control station, the Driver's knees and hips are flexed no greater than 90º. While driving the shoulders are flexed approximately 45º with elbows flexed slightly greater than 90º with respect to the upper arm.

4.2.5.2 Bison Air Sentry

Please note that the Bison utilized in the BTA was not equipped with a family hatch. Based on combat experience, the following results are based upon an expert review of similar Air Sentry tasks. The Bison has two air sentry positions located in the back of the vehicle.

4.2.5.2.1 Tasks

The main task of the Air Sentries is to provide security to the Bison by means of viewing and scanning for any possible threats. The Air Sentries also perform several other minor tasks and together with their main tasks they are all described below:

1) **Donning PPE-** This involves the Air Sentry donning their tactical vest, fragmentation vest and their helmet before they access their vehicle. This takes approximately 30 seconds. Unlike the other crewed positions the Air Sentries did wear their tactical load carriage vest. The majority of Air Sentries did not wear ballistic shoulder pads.
2) **Viewing/ Scanning-** The Air Sentries main task is to continuously scan their arcs for any possible threats to their safety – See Figure 53. This area includes the rear and sides of the Bison keeping eyes on everything that is higher up than the deck of the Bison. If the Air Sentries are in the last vehicle of the convoy they are responsible for everything in the rear.
3) **Access/ Egress-** The Air Sentries access and egress their positions through the inside of the Bison. Once the Air Sentries are inside the Bison via the rear hatch they get into position by standing on the benches in the back of the Bison and exposing their top half of their bodies through the hatch. The Air Sentries egress by first dropping down through the hatch and then exiting through the rear hatch.
4) **Firing Weapon: High Features-** After an IED attack the Air Sentries provide covering fire to the high features to allow soldiers to dismount.
5) **Firing Weapon: On Ground-** If vehicles or people approach the Bison the Air Sentries will engage if they feel that they pose a threat to the safety of them and the crew.
6) **Internal Extraction-** If an Air Sentry is wounded by either an IED or gunfire they are most likely pulled down into the hatch where aid is provided to them.
7) **Waving Off-** If a person or vehicle approaches the Air Sentries they will wave them off with their hands before they throw objects or fire warning shots. This is the same if the person or vehicle approaches from the side or from the rear.

8) **Throwing Objects-** Before firing a warning shot at the incoming person or vehicle the Air Sentries will throw water bottles or pop can to halt any more forward progress.

9) **Vehicle Maintenance-** If their vehicle is disabled the Air Sentries will likely attach tow cables from their vehicle to another vehicle so that it can be towed. The Air Sentries will also likely change the tire if it is necessary. If it is a rear tire that is blown the LAV III will likely continue to travel until it cannot go further without the tire being changed. If it is a front tire then the LAV III will continue to a safe spot and it will be changed as soon as possible.

10) **Reloading Weapon-** The Air Sentries will sometimes have to reload their weapon while they are mounted. This occurs rarely because if they are involved in a firefight they are likely to dismount right away.

4.2.5.2.2 Exposure

During the majority of the tasks performed by the Air Sentries they are exposed through the hatch on the rear. When viewing and scanning everything deck up the Air Sentries are usually waist up in the hatch – See Figure 53. When they engage targets on the high features they slump down into the hatch leaving only their shoulder blades and above exposed. At this time they are leaning up against the interior rim of the hatch. If the Air Sentry is engaging a target on the ground they move forward to the front/ exterior rim of the hatch and depending on the proximity of the person they may have to rise higher than their waist to get an accurate shot. However, if the person or vehicle is approaching on the ground at a further distance then the Air Sentry leans on the interior rim of the hatch and remains naval height above the hatch. The hatch door decreases the Air Sentry's ability to engage targets coming from the side. The hatch door does provide protection to the Air Sentry from the side, leaving only the head, face, and neck exposed from the side. The bottom half of the Air Sentries remain in the same location for the majority of their tasks but will change position depending on the direction the soldier is facing. Whenever the Air Sentries dismount to engage targets or do vehicle maintenance they are fully exposed outside the confines of the vehicle. The Air Sentry is more exposed from the rear as compared to the front. From the rear the Air Sentry is exposed from the waist up – See Figure 53. However, from the front the Air Sentry does have more protection with only their head, face, and neck being exposed – See Figure 54.

Figure 53: Bison Air Sentry Scanning/ Viewing

Figure 54: Bison Crew Exposure from the Front

4.2.5.2.3 Range of Motion

Air Sentries require a significant amount of motion around most of the major joints. Air Sentries require the ability to raise their arms above their head to access and egress to and from the hatch. Due to the fact that the hatch is limited in size the soldiers need to abduct their arms almost 180º in order to get up into and down out of the hatch. The Air Sentries also need sufficient shoulder freedom to perform a throwing motion to ward off approaching vehicles and people. The Air Sentries also need complete elbow motion to access and egress the hatch, as well as, getting into firing position. They also need hip motion up to 90º of flexion to get into position within the hatch. This is the same for motion at the knee joint where up to 90º of flexion, with respect to the thigh, is required to get into position. Air Sentries require sufficient neck movement to scan their arcs and to move freely to engage targets. This can be done within normal neck movements and without approaching the extreme limitations of neck movement.

4.2.5.3 Bison Crew Commander

4.2.5.3.1 Tasks

The main mounted task of the CC is to control the vehicle mounted weapon, scanning for possible threats, give orders to the rest of the crew, as well as, the responsibility for the safety of the vehicle and the crew. A detailed list of tasks performed by the CC is given below:

1) **Donning PPE-** This involves the CC donning their tactical vest, fragmentation vest and their helmet before they access their vehicle. This takes approximately 30 seconds. CC reported that they did not normally wear the tactical vest when mounted as it interferes with moving in and out of hatches.
2) **Viewing/ Scanning-** The CC is in charge of scanning and viewing for IEDs or VBIEDs. When scanning high sides the CC looks upwards both in the forward and side directions.

The CC may also stand on their toes and lean over the side of the Bison to look at trash and garbage on the side of the road. This depends on the height of the CC – See Figure 55.

Figure 55: CC in Viewing/ Scanning Position

The Bison was designed with a very prominent "pulpit" style CC position. While the hatch itself is raised above the vehicle deck the position also includes a substantial ring mount for an adjustable anti-aircraft machinegun.

3) **Engage Targets with C6-** The CC is responsible to engage targets from the front, side, and rear with the vehicle mounted weapons. The design of the machinegun mount raises the height of the C6 high above the hatch – see Figure 56.

Figure 56: Bison CC Demonstrating Height of C6 in Ring Mount

4) **Engage Targets with Personal Weapon-** If enemies approach to a vicinity that the CC is unable to use the vehicle mounted weapons they must switch to their personal weapon (likely the C7 rifle) – See Figure 57.

Figure 57: Bison CC Engaging Target with Personal Weapon

5) **Changing Ammunition -** If the CC runs out of ammunition in their personal weapon they must change the magazine while exposed out of the hatch. As well, CCs are also exposed when they need to reload the C6 machinegun in the ring mount. CCs reported stowing C6 ammunition on the outside of their vehicle and thus are exposed when they reach over or down to grab boxes of linked ammunition.

6) **Unjamming Ammunition in C6-** Occasionally, the ammunition that is fed into the C6 becomes jammed. The CCs responsibility is to free up the jam and ensure the safe operation of the weapon. If this is not possible the CC will switch to his personal weapon until the C6 can be fixed. If there is a need to clear the C6 the CC needs to be high enough to reach the weapon, exposing at least from the waist up (see Figure 56). This leaves him very exposed.

7) **Moving Into and Out of the Hatch-** Depending on the severity of the threat dictates whether the CC is standing up or sitting down in the hatch. Therefore, the CC needs to move freely from and to both positions.

8) **Crouching-** If the threat level increases the CC will crouch down into the hatch with his feet remaining on the seat and his knee joint fully flexed, leaving only the top of his helmet exposed.

4.2.5.3.2 Exposure

For the majority of the tasks performed by the Bison CC, they are standing at a nametag height with the upper chest and shoulders exposed. These tasks include viewing and scanning, engaging targets with C6, and repairing the C6. When travelling through an area of increased threat the CC crouches down in the hatch leaving only the top of the helmet exposed with the rest of their body in between the top of the hatch and the seat. The threat

will dictate how exposed the CC is when firing their C7. The closer the enemy gets the higher the CC needs to be to gain a better vantage point – See Figure 58, while the further the enemy is the lower the CC can be inside the hatch – See Figure 59. The range of exposure for engaging targets with the C7 can range from chin high to waist high above the hatch. The CC is also exposed between the episcopes and ring of the hatch. The parts of the body that are exposed through the railing and episcopes depend on the overall position of the CC.

Figure 58: Bison Driving in a Built-up Area

Figure 59: Bison CC Engaging Target at a Far Distance with C7

4.2.5.3.3 Range of Motion

The CC needs full range of motion of most of the major joints. While repairing the C6 and firing the C7 at targets, the CC performs tasks where his shoulder is flexed to at least 90º and abducted to at least 90º. The CC also requires flexion of the elbow close to 180º when performing repairs on the C6, as well as climbing out of and into the hatch and maintaining viewing and scanning position within the hatch. The CC also requires full knee flexion and extension range for climbing into and out of the hatch. The CC also requires the full range of hip flexion when the CC is crouching down in the hatch (when travelling through an area of increased threat). The CC also requires several degrees of trunk rotation and flexion while leaning over the side of the Bison to engage targets with their C7, as well as, rotating the C6 manually to engage targets at the side and rear of the Bison.

4.2.6 Leopard C2 Tank

The Leopard C2 tank is a highly armoured battle vehicle. It deploys with a crew of four, including a Driver, a CC, a Gunner, and a Loader/ radio operator. It has a 105 mm L7A3 gun that is capable of engaging targets in a vast array of conditions, day/ night, stationary/ moving, and through the use of a fully stabilized fire control system with an integrated thermal imaging system and laser range-finder. It also contains two 7.62 mm C6 machine guns that can be mounted inside the turret and mounted externally on either the CCs or the Loader's station. The Leopard C2 is also fitted with two banks of four smoke grenade launchers on the turret. The Leopard C2 tank is capable of being sealed off against nuclear, biological, and chemical threats – See Figure 60.

Figure 60: Leopard C2 tank

4.2.6.1 Leopard Driver

4.2.6.1.1 Tasks

The main task of the Driver of the Leopard is to maintain driving control of the vehicle in all conditions. Above and beyond normal driving, the Driver performs other minor tasks that are necessary for the operation of the Leopard but for the majority of the tasks the Driver stays in the Drivers position – See Figure 61.

Figure 61: Driver Control Station in the Leopard Tank

4) **Donning PPE-** This involves the Driver donning their fragmentation vest and their helmet before they access their vehicle. This takes approximately 30 seconds. The Driver typically stowed his tactical vest behind his seat.

5) **Driving-** The Driver's station is located at the front, offset to the right of the vehicle's centre line. The Driver is responsible for complete control of the Leopard as it pertains to movement and steering. It was mentioned by a SME that at no time does the Driver ever egress while the Leopard is operational. Driving control of the Leopard includes – steering, acceleration, deceleration, and control buttons – See Figure 62.

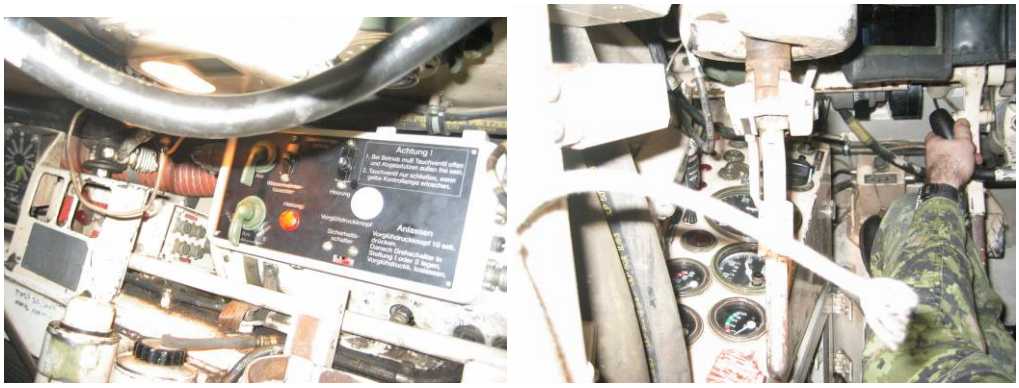

Figure 62: Leopard Driver Control Buttons, a) on the right side, b) on the left side

6) **Normal Access and Egress-** A large, pintle-mounted lift-and-swing type hatch is provided for the Driver and opens to the right. Once inside the tank the Driver has to manoeuvre his way to the Drivers station that is located at the front right of the turret. There are two observation periscopes in the Driver's hatch, plus one to the left of his section, for use when driving closed down.

4.2.6.1.2 Exposure

During the vast majority of operations the Leopard Driver is hatches down with the hatch cover secure. The Driver typically is not directly exposed to IED blasts.

4.2.6.1.3 Range of Motion

The Driver of the Leopard requires full range of hip, knee, and shoulder motion for mounting and dismounting the Leopard, and getting into the Drivers station once mounted onto the tank. Once seated in the Driver control station, the Driver's knees and hips are flexed slightly greater than 90º - See Figure 61. While driving the shoulders are flexed approximately 45º with elbows flexed slightly greater than 90º with respect to the upper arm – See Figure 61.

4.2.6.2 Leopard Crew Commander

4.2.6.2.1 Tasks

The vehicle CC is typically an officer or Non-commissioned officer (NCO) and is responsible for the control and coordination of the vehicle, main weapons and the crew. The CC keeps constant lookout for evidence of IEDs, the enemy, observes the zone for which he is responsible, and attends for any orders from the convoy commander's vehicle. In action, the CC gives his orders to the Driver, Loader and Gunner by radio intercom. If required the CC engages targets using a pintle-mounted machinegun.

The CC is located in the turret, above and to the rear of the gunner on the right hand side. The Loader is located on the left side of the turret. A detailed list of tasks performed by the CC is given below;

1) **Donning PPE-** This involves the CC donning their fragmentation vest and their helmet before they access their vehicle. This takes approximately 30 seconds. The CC mentioned to us that they did not wear their tactical vest because of the tight fit in the hatch and due to the heat of Afghanistan.
2) **Normal Access/ Egress-** The CC accesses his station by mounting the Leopard from the outside and then climbing up the side. The CC egresses by lifting up out of the hatch and climbing down the side of the tank.
3) **Viewing/Scanning-** The CC also scans the environment for potential threats such as, oncoming vehicles, roadside bombs, etc... Scanning usually takes place in the forward and side directions – See Figure 63.

Figure 63: Leopard CC in Normal Viewing/ Scanning Position

4) **Engage Targets with C7-** If an enemy approaches the tank from the side and the crew is unable to utilize the 105 mm main gun or the coaxial machinegun the CC will rise out of his turret and engage with their C7 – See Figure 64 for a picture of the Loader in the firing position. The CC would be in the same position as the Loader just on the alternate side of the Leopard. It should be noted that ROE restrict the use of the Leopard's main gun and coaxial machinegun if there is a risk to non-combatants. When driving through "peaceful" villages CC have to utilize personal weapons for emergency self-defence.

Figure 64: Loader in C8 Firing Position (same as CC)

5) **Crouching-** If the threat from the enemy escalates and the CC feels threatened from being up in the turret they will crouch down into the turret (go hatches down).

6) **'Prairie Dogging'-** This is what the CC does to view an area close to the tank. Due to the fact that the CC sits low into the turret they only have visibility at a far distance. In order to view things close to the tank the CC must hop up in the turret and bend over the side, look, and then fall back into the turret. This is described as 'prairie dogging'.

4.2.6.2.2 Exposure

For the majority of the tasks, the Leopard CC is protected by the turret and only the head exposed – See Figure 65. If the CC is engaging targets with their C7, the CC is naval high above the turret leaving almost their entire upper body exposed – See Figure 64. When the CC 'prairie dogs' their entire upper body is exposed, including the pelvis.

4.2.6.2.3 Range of Motion

The CC needs full range of motion for the shoulder and elbow joints. In order for the CC to egress the hatch or 'prairie dog' they must abduct their shoulders to approximately 90º to get them out of and on top of the turret so they can use their arms as leverage to pop out of the turret. They also require almost 180º of shoulder flexion to access the handhold while mounting and dismounting the Leopard. They also require full elbow flexion for accessing

and egressing the turret, mounting and dismounting the Leopard, as well as, getting into firing position with the C7. The CC requires enough knee and hip range that will allow them to mount and dismount the Leopard, as well as, getting into and out of the turret. This requires greater than 90º of knee flexion and almost 90º of hip flexion.

Figure 65: Exposure of Both the CC (left) and the Loader (right)

4.2.6.3 Leopard Gunner

4.2.6.3.1 Tasks

The main task of the Gunner is to sight and operate the major weapons of the Leopard (105mm main gun and coaxial machinegun). The Gunner also performs a few other minor tasks. All tasks are described below:

1) **Donning PPE-** This involves the Gunner donning their fragmentation vest and their helmet before they access their vehicle. This takes approximately 30 seconds. The Gunner mentioned to us that they did not wear their tactical vests because of the tight fit in the confines of the vehicle. Gunners also commented that because of the significant heat stress in the gunner's station they remove any extra pieces of protective gear.
2) **Normal Access/ Egress-** The Gunner accesses his station by mounting the Leopard from the outside and then climbing up the side and then climbing down the CCs turret and into the Gunner's station. The Gunner egresses by climbing out of the turret and climbing down the side of the tank.
3) **Viewing/ Scanning-** The Gunner uses the optics within his station to scan for threats. However, most of viewing tasks are once the target has already been identified and the Gunner has to find it within their sights prior to engagement.
4) **Accessing and Operating Controls-** The Gunner has to access a variety of controls that are critical to the operation of the vehicle weapons. The Gunner uses his hands to reach for these controls that are typically in front of him – See Figure 66.

Figure 66: Gunner Reaching for Controls

5) **Firing Vehicle Weapons-** The main task of the Gunner is to control, and fire, the main vehicle weapons. This involves the Gunner using his sights and controlling the weapon with the hand controllers and firing once the target has been acquired – See Figure 67.

Figure 67: Gunner Acquiring Target and Preparing to Fire

4.2.6.3.2 Exposure

The Gunner normally experiences little exposure because most of the time he sits inside buried within the tank.

4.2.6.3.3 Range of Motion

All of the Gunners controls are within close reach. He is normally facing forward and experiences minimal head, neck, and arm movement. In order for the Gunner to egress the CC hatch they must abduct their shoulders to approximately 90º to get them out of and on top of the turret so they can use their arms as leverage to pop out of the turret. They also require almost 180º of shoulder flexion to access the handhold while mounting and dismounting the Leopard. They also require full elbow flexion for accessing and egressing the turret, mounting and dismounting the Leopard. The Gunner requires enough knee and hip range that will allow them to mount and dismount the Leopard, as well as, getting into and out of the turret. This requires greater than 90º of knee flexion and almost 90º of hip flexion.

4.2.6.4 Leopard Loader

4.2.6.4.1 Tasks

The primary task of the Loader is to load the main gun and secondary machinegun ammunition. If the main gun is not in use the loader assists the CC in scanning tasks. Loaders are also responsible for the vehicle's communication systems. Loader tasks include:

1) **Donning PPE**- This involves the Loader donning their tactical vest, fragmentation vest and their helmet before they access their vehicle. This typically takes approximately 30 seconds.
2) **Normal Access/ Egress-** The Loader accesses their station by mounting the Leopard from the outside, climbing up the side and then entering through the Loader's circular hatch in the turret. The Loader egresses by climbing out of the turret through his/her hatch and climbing down the side of the tank.
3) **Viewing/ Scanning-** Like the CC, the Loader scans the environment for potential threats. They conduct this task concurrently. Scanning usually takes place in the forward and side directions.
4) **Loading Main-gun Ammunition-** The Loader must drop down into the turret through his/her hatch and load the main gun ammunition individually.
5) **Clearing Stoppages -** If there is a suspected problem with the main gun ammunition, it is the Loader's task to attend to the problem. The Loader will drop into the turret and use a tool (bar) to open the closed breech and to pull the problem - see Figure 68. The Loader is also responsible for clearing stoppages in the coaxial machinegun. This requires the loader to open the C6 feed tray and to clear the problem.

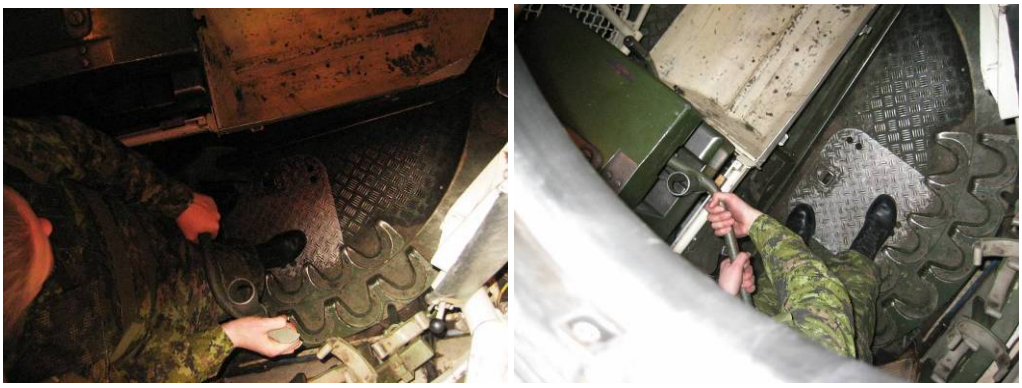

Figure 68: Leopard Loader Clearing Stoppage

4.2.6.4.2 Exposure

The Loader experiences much of the same exposure as the CC. When loading the tank ammunition, the Loader is in the turret, therefore experiences no exposure. During the remainder of their tasks they are within the protection of the turret with only their head exposed. Figure 69 shows the typical exposure of the Loader.

Figure 69: Leopard Loader's Typical Hatches Up Exposure

4.2.6.4.3 Range of Motion

The Loader needs full range of motion for the shoulder and elbow joints. In order for the Loader to egress the hatch they must abduct their shoulders to approximately 90º to get them out of and on top of the turret so they can use their arms as leverage to pop out of the turret. They also require almost 180º of shoulder flexion to access the handhold while mounting and dismounting the Leopard. They also require full elbow flexion for accessing and egressing the turret, mounting and dismounting the Leopard. The Loader requires enough knee and trunk range that will allow them to bend and load the ammo in the turret. This requires less than 30º of knee flexion and almost 45º of hip flexion.

4.2.7 Coyote Light Armoured Vehicle -Reconnaissance (LAV-Recce)

The Coyote is a highly mobile, well-armed and well-protected reconnaissance variant of the LAV family. It is used both in the conduct of battlefield reconnaissance and surveillance missions and as a convoy escort and mounted patrol vehicle. The coyote has a ballistic-steel hull which protects against small-arms fire, mines and high explosive airbursts. It also contains a two-man electric-drive turret that is equipped with a laser-warning receiver – See Figure 70.

Figure 70: Coyote Armoured Vehicle

4.2.7.1 Coyote Driver

4.2.7.1.1 Tasks

The main task of the Driver of the Coyote is to maintain driving control of the vehicle in all conditions and perform general maintenance duties. Coyote Driver tasks include:

1) **Donning PPE-** This involves the Driver donning their fragmentation vest, and their helmet before they access their vehicle. This takes approximately 30 seconds. Coyote drivers reported that the vehicle's hatch was too small to wear tactical vest on top of a fragmentation vest. Additionally all of the Drivers interviewed had removed their fragmentation vest shoulder flaps because of snagging problems.
2) **Driving-** The Driver is responsible for complete control of the Coyote as it pertains to movement and steering. This vehicle is used for reconnaissance. On roads, the LAVs maximum speed is 100 km/h, with a maximum range of 660 km. There are three indirect-view ports that enable the Driver to see when they are sitting hatches down.
3) **Navigation-** The Driver monitors the Tactical Navigation System (TACNAV) that provides co-ordinates of the Coyote's current position. The Driver may program it to indicate way-points along a predetermined route.
4) **Normal Access/Egress-** The Driver accesses his station via the Driver hatch that is located at the front left of the Coyote.

5) **Vehicle Maintenance-** The Driver is responsible for the general maintenance of the Coyote and if they experience problems outside the wire the Driver will attempt to diagnose the problem and may attempt to fix it.

4.2.7.1.2 Exposure

The participants reported that the Driver may drive "hatches out" in the countryside. If so the Driver is exposed from the shoulders up.

Figure 71: Coyote Driver Demonstrating Hatches-Up Exposure

4.2.7.1.3 Range of Motion

The Driver of the Coyote requires full range of hip, knee, and shoulder motion for mounting and dismounting the Coyote, and getting into the Drivers station. Once seated in the Driver control station, the Driver's knees and hips are flexed no greater than 90º. While driving the shoulders are flexed approximately 45º with elbows flexed slightly greater than 90º with respect to the upper arm.

4.2.7.2 Coyote Crew Commander

4.2.7.2.1 Tasks

The Coyote CC is typically an officer or Non-commissioned officer (NCO) and is responsible for the control and coordination of the vehicle, main weapons and the crew. The CC keeps constant lookout for evidence of IEDs, the enemy, observes the zone for which he is responsible, and attends for any orders from the convoy commander's vehicle. In action, the CC gives his orders to the Driver and Gunner by radio intercom. If required the CC engages targets using a pintle-mounted machinegun.

A list of tasks performed by the CC is given below;

1) **Donning PPE**- This involves the CC donning their fragmentation vest, and their helmet before they access their vehicle. This takes approximately 30 seconds. Coyote CC reported that they did not wear their tactical vests or ballistic shoulder flaps in the Coyote. The vest and shoulder caps are a snagging hazard and slow CC movement up and down in the turret.

2) **Normal Access/ Egress**- The CC accesses his station via his own hatch. It is located on the right side of the Coyote.

3) **Viewing/Scanning**- The CC also scans the environment for potential threats such as, oncoming vehicles, roadside bombs, etc.

4) **Monitor Comms**- The CC uses the communication system to communicate with the crew within the vehicle on the intercom and by radio to other units.

5) **Control Weapons**- In addition to his personal weapon, the CC can control the main gun and machinegun using the manual gun-traverse lever. He also is responsible for the control of the Control Display Assembly (CDA) which arms and controls the Coyote's weapon systems, 25mm machine gun and smoke grenade launchers.

6) **Engage Targets with the Pintle-mounted C6-** The CC can also engage targets with the pintle-mounted C6. The Coyote pintle mount is primarily designed for anti-aircraft defence and not for engaging close-in targets. The participants in this trial reported that they would not use the pintle-mounted machinegun as it exposes the CC significantly, they believed that the coaxial machinegun is a much more effective secondary weapon (please note that the crews in this study never had to engage two dispersed targets simultaneously).

4.2.7.2.2 Exposure

The CCs normal position entails keeping his head out (as seen in Figure 72). Therefore, his face and neck are usually fully exposed. While most of his body is protected by the turret, the CC is generally exposed from the shoulders up.

Figure 72: Coyote CC Exposure

4.2.7.2.3 Range of Motion

The CC of the Coyote requires full range of hip, knee, and shoulder motion for mounting and dismounting the Coyote, and getting into the CC station once through the CC hatch on the Coyote. Once seated in the CC control station, the CCs knees and hips are flexed no greater than 90º. While driving the shoulders are flexed approximately 45º with elbows flexed slightly greater than 90º with respect to the upper arm.

4.2.7.3 Coyote Gunner

4.2.7.3.1 Tasks

1) **Donning PPE**- This involves the Gunner donning their fragmentation vest, and their helmet before they access their vehicle. This takes approximately 30 seconds. Coyote gunners reported that they did not wear their tactical vests or ballistic shoulder flaps in the Coyote. The vest and shoulder caps are a snagging hazard and slow gunner movement up and down in the turret.
2) **Normal Access/ Egress**- The Gunner accesses his station via his own hatch. It is located on the Coyote turret on the left side.
3) **Viewing/Scanning**- The Gunner also scans the environment for potential threats such as, oncoming vehicles, roadside bombs, etc.
4) **Accessing Personal Weapon-** Figure 73 shows where a Gunner keeps his kit on the Coyote. It is within an arm's reach on his left hand side.
5) **Engage Targets with C6-** The Gunner is responsible to engage targets from the front, side, and rear with the vehicle mounted weapons. The height of the handles of the vehicle mounted weapon from the top of the hatch is approximately 40 cm.

Figure 73: Coyote Gunner's Personal Weapon Storage

4.2.7.3.2 Exposure

The Gunner experiences similar exposure as the CC. The Gunner typically sits up such that he is exposed from the shoulders up (see Figure 74). The face and neck are fully exposed.

Figure 74: Coyote Gunner Typical Exposure

Some CC and gunners are smaller in stature and may be required to stand versus sit when engaging targets with the mounted weapon. As seen in Figure 75, this participant is demonstrating a firing position that some smaller Gunners and CC must use. This leaves them almost totally exposed, except for the bottom half of his left leg.

Figure 75: Coyote Gunner Shooting a C6

4.2.7.3.3 Range of Motion

The Gunner of the Coyote requires full range of hip, knee, and shoulder motion for mounting and dismounting the Coyote, and getting into the Gunner station once through the Gunner hatch on the Coyote. Once seated in the Gunner control station, the Gunner's knees and hips are flexed no greater than 90º. While driving the shoulders are flexed approximately 45º with elbows flexed slightly greater than 90º with respect to the upper arm.

As seen in Figure 76, the Coyote Gunner has limited room in his compartment. His shoulders almost touch the edge of the hatch. Wearing shoulder pads would obviously restrict movement further. Participants reported they seldom wear shoulder pads for this reason.

Figure 76: Coyote Gunner Compartment

4.2.7.4 Coyote Surveillance Operator

The Coyote Surveillance Operator's duties vary as per the vehicle's task. If the vehicle is assigned a surveillance task the Operator will control the vehicles surveillance equipment (i.e. mast-mounted sensors) from the operator's station in the back of the Coyote. If the vehicle is assigned to an escort or mounted patrol task the Surveillance Operator will act as an Air Sentry. In Afghanistan Surveillance Operators will typically act as Air Sentries when the Coyote is on the move. Typical operator tasks are detailed below.

4.2.7.4.1 Tasks

1) **Donning PPE**- This involves the Operator donning their fragmentation vest, tactical vest, and their helmet before they access their vehicle. This takes approximately 30 seconds. Unlike other Coyote crewmembers, Operators reported that they did wear the tactical vest inside the Coyote.
2) **Normal Access/ Egress-** The Operator accesses his Operator Control Station (OCS) via the right rear door – see Figure 77. In Afghanistan the normal station of the Surveillance Operator is in the family hatch acting as an Air Sentry. The Operator accesses his Air Sentry position through the right rear door and then up through the family hatch – see Figure 80.

Figure 77: Coyote Rear Doors

Air Sentry- The main task of the Air Sentry is to provide security to the Coyote by means of viewing and scanning for any possible threats. The Air Sentry also performs several other minor tasks and together with their main tasks they are all described below.

- The Air Sentries main task is to continuously scan their arcs for any possible threats to the vehicle's safety; this area includes the rear and sides of the Coyote.
- When stopped for a long halt the Air Sentry will normally dismount and provide protection to the vehicle.
- If required the Air Sentry will engage targets with their personal weapon.

3) **Operate Surveillance Equipment-** The Operator operates all the OCS controls, the thermal observation device or a thermal imager, camera, and a laser range finder. Seated at the OCS (see Figure 78), the Surveillance Operator is able to monitor information received from the remote or mast-mounted sensors. The Operator uses a keyboard, joystick, and other controls on a Command Entry Unit (CEU) situated immediately below the video display monitor.

Figure 78: Coyote Operator Control Station

4.2.7.4.2 Exposure

During the vast majority of surveillance operations the Operators are located within the confines of the OCS as depicted above in Figure 78; here they experience no exposure. If the Coyote is assigned a convoy escort or vehicle patrol task, the Operator acts as an Air Sentry and is exposed from the shoulder up.

Figure 79: Surveillance Operator Exposure as an Air Sentry

4.2.7.4.3 Range of Motion

The Coyote operator participants reported that they have difficulty getting through the family hatch. As seen in Figure 80 (left), the space is small to manoeuvre comfortably. When opening the family hatch, there is a need to reach up and rotate the hatch handle with shoulder extension at 90° (see Figure 80 right). This is difficult when wearing shoulder pads as it would further inhibit movement.

Figure 80: Coyote Operator Egress Through Family Hatch

4.2.8 Light Armoured Vehicle (LAV III)

The Light Armoured Vehicle (LAV) is a fast, well armed, state of the art troop carrier that serves the need of mounted infantry. This vehicle is highly versatile and is used in all weather conditions,

day or night, and on most types of terrain. When used as an infantry section carrier, the LAV III deploys with a vehicle commander, a Gunner, a Driver, and seven infantry soldiers. A LAV III is shown below – See Figure 81.

Figure 81: LAV III

4.2.8.1 Driver

4.2.8.1.1 Tasks

The main task of the Driver of the LAVIII is to maintain driving control of the vehicle in all conditions. All LAVIII Driver tasks include:

1) **Donning PPE-** This involves the Driver donning their fragmentation vest and their helmet before they access their vehicle. This takes approximately 30 seconds. Driver's reported that they did not wear the tactical vests inside the LAVIII, but placed them in beside them or behind their seat.
2) **Driving-** The Driver is responsible for complete control of the LAVIII as it pertains to movement and steering. The Driver normally stores his gear and weapon to his left hand side. They typically do not use their weapon as it is not part of their routine tasks.
3) **Normal Access and Egress-** The Driver has to access the Driver's station via his hatch. The participants reported that the size of the hatch will not fit all Drivers (i.e. it is too small). Drivers usually have to lift their hands up over their head to get in. To get out they must lift themselves out by propping their arms against the hatch rim.

4.2.8.1.2 Exposure

The LAV III is typically driven hatches down by the Driver and as such the Driver is not exposed. The participants reported that the LAV III Driver may drive "hatches out" in the countryside. Hatches out driving exposes the Driver from approximately the shoulders up, including his head and neck.

4.2.8.1.3 Range of Motion

The LAV III Drivers reported that they have easy access and enough room to operate controls at their Driver's station (see Figure 82). They reported that the most difficult motion is mounting the LAV III.

Figure 82: LAV III Driver in Hatch

4.2.8.2 Crew Commander

4.2.8.2.1 Tasks

The main task of the CC is to scan for possible threats, give orders to the rest of the crew, as well, they are responsible for the safety of the vehicle and the crew. A detailed list of tasks performed by the CC is given below;

1) **Donning PPE-** This involves the CC donning their fragmentation vest and their helmet before they access their vehicle. This takes approximately 30 seconds. CC reported that they did not wear the tactical vests inside the LAV III, but placed them in the bustle bin at the side of the turret. CC reported that they typically do not wear ballistic shoulder pads because of the snagging problem.
2) **Normal Access and Egress-** The CC has to access the CC station via his hatch located on the right side on the LAV III.
3) **Engage Targets with Pintle-Mounted C6 -** The CC can engage secondary targets with the pintle-mounted C6. The LAV III pintle mount is primarily designed for anti-aircraft defence and not for engaging close-in targets.
4) **Engage Targets with Personal Weapon**- The CC in the LAV III keeps his rifle off to his right hand side in the storage basket (see Figure 83 left). Access to the rifle requires an extended reach. In addition to their C7 rifle, many CC also carry pistols. Operational experience in Afghanistan has shown that curious bystanders may not obey warnings to stay back when a rifle was pointed at them but do when a pistol is used because of its association with authority. Figure 83 (right) shows the CC aiming a pistol over the back deck.

Figure 83: LAV III CC Access to Personal Weapon (left), Aiming Pistol Over Back Deck (right)

4) **Viewing/Scanning-** The CC also scans the environment for potential threats such as, oncoming vehicles, roadside bombs, etc... Scanning usually takes place in the forward and side directions. The CC participants reported that their view to the sides was fairly restrictive. There is a need for them to lean over to see over the sides.

4.2.8.2.2 Exposure

Typical exposure of the CC is from their mid-chest and up. Figure 84 shows the typical exposure of a LAV III CC with his arms resting on the episcopes or on the hatch ring. His face, neck, and arms are fully exposed.

Figure 84: LAV III CC Typical Exposure

When shooting close-in targets or over walls the CC is exposed approximately from the waist up – See Figure 85, where his arms, sides, face and neck are exposed. Figure 86 shows the CC demonstrating how high he would have to be to use a mounted weapon, such as a C6.

Figure 85: LAV III CC Demonstrating Engaging Close-In Targets or Over Walls

If the CC were to shoot using the pintle-mounted C6 his arms, sides, face and neck would be exposed (see Figure 86). Participants reported that they did not like having to use the mounted C6 because of the associated exposure. Figure 86 (right) shows the position of the CC when engaging targets over the side (note the soldier is demonstrating the position with his C7A2).

Figure 86: LAV III CC Exposure to use Pintle-Mounted C6

4.2.8.2.3 Range of Motion

To fire out the back deck (see Figure 83, right), the CC needs full trunk rotation. His shoulder flexion would be approximately 90°. For viewing and scanning tasks, the CC needs 180° neck rotation.

4.2.8.3 Gunner

4.2.8.3.1 Tasks

1) **Donning PPE-** This involves the Gunner donning their tactical vest, fragmentation vest and their helmet before they access their vehicle. This takes approximately 30 seconds. Gunner's reported that they did not wear the tactical vests inside the LAV III, but placed them in the bustle bin at the left side of the turret. Gunner's reported that they typically do not wear ballistic shoulder pads because of compatibility issues.

2) **Normal Access and Egress-** The Gunner has to access the Gunner station via his hatch located on the left side on the LAV III.

3) **Viewing/Scanning-** In conjunction with the CC, the Gunner also scans the environment for potential threats such as, oncoming vehicles, roadside bombs, etc.

4) **Access to Personal Weapon**- The Gunner in the LAV III keeps his rifle off to his left hand side in the storage basket. This is a bit of a reach for him, as he must extend his arms and also bend and reach downward to access it. Figure 87 shows the Gunner firing a pistol over the back deck. Gunner's reported that Rules of Engagement (ROE) may limit the use of the 25mm canon and coaxial machineguns in cities and towns (i.e. limit collateral damage to a non-combatant population). As a result gunners are routinely forced to move to a hatches-up position and use personal weapons for defence.

Figure 87: LAV III Gunner Aiming Over the Back Deck

5) **Monitor Controls-** The Gunner is responsible for the control of the main gun. Figure 88 shows the Gunner's station.

Figure 88: LAV III Gunner's Station

4.2.8.3.2 Exposure

Similar to the exposure of the LAV III CC, the Gunner has typical exposure from the mid-chest up (around the name tag area – see Figure 89). His arms are out, and neck, face, and shoulders (when shoulder pads are not worn) are exposed.

Figure 89: LAV III Gunner Typical Exposure

4.2.8.3.3 Range of Motion

To fire out the back deck (see Figure 83, right), the Gunner needs full trunk rotation. His shoulder flexion would be approximately 90°. For viewing and scanning tasks, the Gunner needs 180° neck rotation.

4.2.8.4 Air Sentries

The LAV III has two Air Sentry positions located in the back of the vehicle. Air Sentries are provided by the remainder of the infantry section. While Air Sentries typically use their own personal weapon, one CC indicated that he had taken the C6 machinegun from his pintle mount and given it to his Air Sentries.

4.2.8.4.1 Tasks

The main task of the Air Sentries is to provide security to the LAV III by means of viewing and scanning for any possible threats. The Air Sentries also perform several other minor tasks and together with their main tasks they are all described below:

1) **Donning PPE-** This involves the Air Sentry donning their tactical vest, fragmentation vest and their helmet before they access their vehicle. This takes approximately 30 seconds. Unlike the other crew positions the Air Sentries did wear their tactical load carriage vest. The majority of Air Sentries did not wear ballistic shoulder pads.

2) **Viewing/ Scanning-** The Air Sentry's main task is to continuously scan their arcs for any possible threats to their safety. This area includes the rear and sides of the LAV III keeping eyes on everything that is higher up than the deck of the LAV III. If the Air Sentries are in the last vehicle of the convoy they are responsible for everything in the rear – See Figure 90.

Figure 90: LAV III Air Sentry Scanning a) Just Above Deck Height, b) High Features

11) **Access/ Egress-** The Air Sentries access and egress their positions through the inside of the LAV III. Once the Air Sentries are inside the LAV III via the rear hatch they get into position by standing on the benches in the back of the LAV III and expose the top half of their bodies through the hatch – See Figure 91. The Air Sentries egress by first dropping down through the hatch and then exiting through the rear hatch.

Figure 91: LAV III Air Sentries Accessing Hatch from Inside

12) **Firing Weapon: High Features-** After an IED attack the Air Sentries provide covering fire to allow soldiers to dismount – See Figure 92.

Figure 92: LAV III Air Sentries Providing Fire to High Features

13) **Firing Weapon: On Ground-** If vehicles or people approach the LAV III the Air Sentries will engage if they feel that they pose a threat to their safety or that of the crew – See Figure 93.

14) **Internal Extraction-** If an Air Sentry is wounded by either an IED or gunfire they are most likely pulled down into the hatch where aid is provided to them.

Figure 93: LAV III Air Sentry Engaging Target on Ground

15) **Waving Off-** If a person or vehicle approaches the Air Sentries they will wave them off with their hands before they throw objects or fire warning shots. This is the same if the person or vehicle approaches from the side or from the rear – See Figure 94.

Figure 94: LAV III Air Sentry Waving off Approaching Person

16) **Throwing Objects-** Before firing a warning shot at the incoming person or vehicle the Air Sentries will throw water bottles or pop can to halt any more forward progress.

17) **Vehicle Maintenance-** If their vehicle is disabled the Air Sentries will likely attach tow cables from their vehicle to another vehicle so that it can be towed. The Air Sentries will also likely change the tire if it is necessary. If it is a rear tire that is blown the LAV III will likely continue to travel until it cannot go further without the tire

being changed. If it is a front tire then the LAV III will continue to a safe spot and it will be changed as soon as possible.

18) **Reloading Weapon-** The Air Sentries will sometimes have to reload their weapon while they are mounted. This occurs rarely because if they are involved in a firefight they are likely to dismount right away.

4.2.8.4.2 Exposure

During the majority of the tasks performed by the Air Sentries they are exposed through the hatch on the rear. When viewing and scanning everything deck up the Air Sentries are usually waist up in the hatch. When they engage targets on the high features they slump down into the hatch leaving approximately 40 – 50 cm of the Air Sentry exposed. At this time they are leaning up against the interior rim of the hatch – See Figure 92. If the Air Sentry is engaging a target on the ground they move forward to the exterior rim of the hatch and depending on the proximity of the person they may have to rise higher than their waist to get an accurate shot – See Figure 93. However, if the person or vehicle is approaching on the ground at a further distance then the Air Sentry leans on the interior rim of the hatch and remains naval height above the hatch – See Figure 95. The bottom half of the Air Sentries remain in the same location for the majority of their tasks but will change position depending on the direction the soldier is facing – See Figure 91. Whenever the Air Sentries dismount to engage targets or do vehicle maintenance they are fully exposed outside the confines of the vehicle.

Figure 95: LAV III Air Sentry Engaging Target on Ground at a Far Distance

4.2.8.4.3 Range of Motion

Air Sentries require a significant amount of motion around most of the major joints. Air Sentries require the ability to raise their arms above their head to access and egress to and from the hatch. Due to the fact that the hatch is limited in size (67 x 53 cm) the soldiers need to abduct their arms almost 180º in order to get up into and down out of the hatch. The Air Sentries also need sufficient

shoulder freedom to perform a throwing motion to ward off approaching vehicles and people. The Air Sentries also need complete elbow motion to access and egress the hatch, as well as, getting into firing position – See Figure 95. They also need hip motion up to 90º of flexion to get into position within the hatch – See Figure 91. This is the same for motion at the knee joint where up to 90º of flexion, with respect to the thigh, is required to get into position – See Figure 91. Air Sentries require sufficient neck movement to scan their arcs and to move freely to engage targets. This can be done within normal neck movements and without approaching the extreme limitations of neck movement.

4.3 Evaluation of Current In-Service Personal Protective Equipment (PPE)

At the end of each session of the BTA, the participants completed a questionnaire to rate their current in-service PPE suite. Using the standard seven-point scale of acceptance, participants rated their in-service PPE in the context of their operational theatre experience – See Figure 96. In addition to objective ratings using the scale, participants were given the opportunity to make subjective comments and/or suggestions regarding their current PPE.

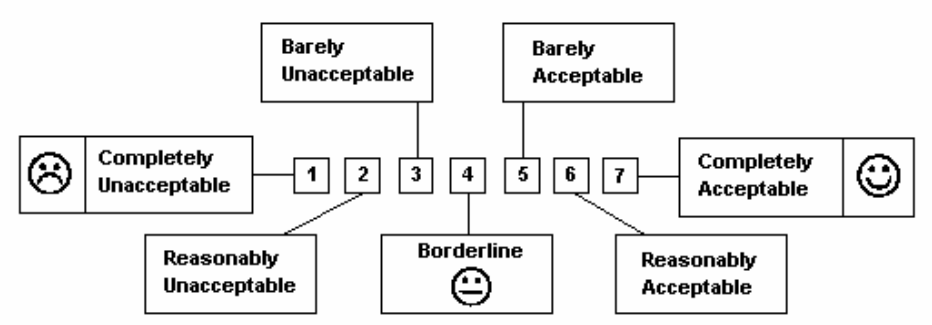

Figure 96: Standard 7-point Acceptability Scale

The results from the in-service PPE questionnaires are presented and summarized in the subsequent sections for each of the following questionnaire areas:

- Ballistic Coverage
- Compatibility
    - Clothing
    - Weapons and Equipment
    - Mounted Crewman Tasks
    - Dismounted Crewman Tasks
- Physical Discomfort
- Thermal Discomfort
- Range of Motion

The number of responses (N) to the PPE questionnaires varied, as not all participants have utilized all PPE identified in the questionnaire. The number of responses is stated for each area of evaluation.

4.3.1 Ballistic Coverage

The questionnaire asked participants to rate the acceptability of PPE ballistic coverage for 12 different body zones. The acceptability rating was based on a scale of 1 to 7, with completely unacceptable at 1, borderline at 4, and completely acceptable at 7. Additionally participants were specifically asked to provide comments for unacceptable ratings. These comments are attached at Annex C.

Overall, approximately 77% of the participants rated the coverage provided by the in-service PPE as being acceptable. The acceptability of PPE coverage varied dramatically between body regions. The upper chest and back body regions received the highest acceptance rating for PPE coverage (96%), while the groin received the lowest scores (25% acceptance).

While 77% of the participants rated overall coverage as being acceptable, the level of satisfaction was just Borderline to Barely Acceptable (4.4 ± 1) when averaged across all 12 ballistic coverage zones. Specific body zone rating results are detailed in Table 2. Shading is used to indicate unacceptable results (less than 50% acceptance or a mean rating of 4).

The results indicated that only upper chest, upper back, abdomen, and lower back ballistic coverage zones were rated as being Barely to Reasonably Acceptable. It should be noted that these areas are protected by the in-service fragmentation vest. Conversely, the participants rated the throat, groin, pelvis, upper arms, and legs zones as being Barely to Reasonably Unacceptable for PPE coverage. The remaining three ballistic coverage zones, side of torso, neck and shoulders were also rated as being Borderline to Barely Unacceptable for PPE coverage.

Table 2: Ballistic Coverage Acceptability Results

Overall ballistic coverage area	Percentage of subjects rating PPE coverage as acceptable	Acceptability Rating
		Mean ± S.D.
Upper chest (N=28)	96%	5.6 ± 1.1
Upper back (N=28)	96%	5.6 ± 1.1
Abdomen (N=27)	85%	5.3 ± 1.6
Lower back (N=28)	79%	4.8 ± 1.5
Side of torso (N=26)	46%	3.5 ± 1.5
Throat (N=20)	35%	2.8 ± 2.0
Neck (side & back) (N=24)	58%	3.6 ± 1.7
Groin (N=20)	25%	2.2 ± 1.8
Pelvis (N=19)	32%	2.5 ± 1.9
Shoulder (N=26)	54%	3.6 ± 1.6
Upper arms (N=21)	29%	2.7 ± 1.5
Legs (N=19)	32%	2.3 ± 1.8
Overall coverage rating (N=22)	77%	4.4 ± 1.0

A number of comments were received on PPE coverage for the throat, side, pelvis and groin areas. These comments are summarized below in Table 3.

Table 3: Ballistic Coverage Comments

COMMENT AREAS AND EXAMPLES	N
ISSUES WITH SIDE PROTECTION: • SIDE PROTECTION NEEDED • SIDE COULD USE MORE PROTECTION LIKE SMALL PLATES	5
ISSUES WITH GROIN PROTECTION: • GROIN NOT COVERED ENOUGH • GROIN, PELVIS AND NECK NEED IT ONLY IF STATIC POSITION	5
ISSUES WITH THROAT /NECK PROTECTION: • NEED THROAT, PELVIS AND NECK PROTECTION • NEED SOMETHING FOR THROAT	5
ISSUES WITH PELVIS PROTECTION: • NEED THROAT, PELVIS AND NECK PROTECTION • PELVIS BARELY COVERED	5

The results suggest that participants believed that while the protection provided by the in-service PPE is acceptable, PPE coverage should/could be improved at the side of torso, neck, throat and pelvis zones. Discussions identified that participants believed that additional lower body protection was task dependent; they commented that added coverage was more important for semi-static personnel (dedicated vehicle crews) but not those who typically dismount (air sentries, section members, etc).

4.3.2 Compatibility

The questionnaire asked participants to rate the acceptability of the compatibility of the in-service PPE with different clothing, weapons, equipment, mounted tasks and dismounted tasks using the 7-point scale.

Given the similarity of task demands between vehicles, participant responses are presented by crew position:

- CC/ Loader/ Gunner position includes:
    - LAV III CCs, Leopard CCs, LAV III Gunners, Leopard Gunner and Leopard Loaders
- Air Sentry position includes:
    - LAV III and Coyote
- Driver position includes:
    - LAV III, TLAV, Leopard Drivers, HLVW and G-Wagon

Please note the sample size varies between crew positions.

4.3.2.1 Clothing compatibility

Participants were asked to rate the acceptability of the in-service PPE for compatibility with clothing, helmets and load carriage.

Overall, approximately 82% of the participants rated the compatibility of the in-service PPE and clothing and equipment as being acceptable – See Table 4**Error! Reference source not found.**. The compatibility acceptability of PPE with clothing and equipment varied between vehicle position and clothing item. Compatibility was rated higher by vehicle Drivers (100%) and lowest by Air Sentries. It should be noted that Air Sentries typically wear their tactical load carriage vests at all times and frequently deploy carrying small packs with extra ammunition. Conversely Drivers typically did not wear their tactical vests when mounted. Caution is recommended when interpreting these results due to the relatively low sample size.

Table 4: Clothing Compatibility Percentage Acceptability Results

Clothing Compatibility	Air Sentry	Driver	CC/ Loader/ Gunner	Overall
	Percentage of ≥ 4, Borderline (n)	Percentage of ≥ 4, Borderline (n)	Percentage of ≥ 4, borderline (n)	Percentage of ≥ 4, borderline (n)
CVC Crew helmet	100% (2)	67% (6)	83% (6)	79% (14)
IECS middle layer jacket	100% (5)	90% (10)	90% (10)	92% (25)
Small pack	50% (6)	90% (10)	80% (10)	77% (26)
Tactical vest	50% (6)	82% (11)	70% (10)	70% (27)
Fragmentation Vest	100% (4)	100% (9)	90% (10)	96% (23)
CG634 helmet	50% (6)	100% (9)	100% (7)	86% (22)
Overall compatibility	40% (5)	100% (9)	88% (8)	82% (22)

The overall level of satisfaction with clothing compatibility was Borderline to Barely Acceptable (4.9 ± 0.8). The level, of satisfaction was lowest for the Air Sentries and highest for the Drivers – see Table 5. Shading is used to indicate unacceptable ratings.

Table 5: Overall Clothing Compatibility Acceptability Results

Clothing Compatibility	Air Sentry	Driver	CC/ Loader/ Gunner
	Mean ±S.D.(n)	Mean ±S.D.(n)	Mean ±S.D.(n)
CVC Crew helmet	4.5 ± 0.7 (2)	4.3 ± 2.3 (6)	5.0 ± 1.4 (6)
IECS middle layer jacket	5.4 ± 0.9 (5)	5.3 ± 1.1 (10)	4.3 ± 1.1 (10)
Tactical Vest	3.2 ± 2.4 (6)	4.3 ± 1.8 (11)	4.2 ± 1.5 (10)
Fragmentation Vest	4.5 ± 1.5 (4)	5.8 ± 1.8 (9)	4.6 ± 1.0 (10)
Small pack	3.8 ± 2.4 (5)	5.1 ± 1.1 (10)	4.8 ± 1.5 (10)
CG634 helmet	3.5 ± 2.3 (6)	5.8 ± 0.8 (9)	5.6 ± 1.3 (7)
Overall compatibility	3.6 ± 1.3 (5)	5.3 ± 0.7 (9)	4.9 ± 0.8 (8)

The results suggest that in general the compatibility of the in-service PPE with other clothing items is good.

4.3.2.2 Weapon and Equipment Compatibility

Participants were asked to rate the acceptability of the in-service PPE for compatibility with weapons and other items of equipment.

Overall, approximately 81% of the participants rated the compatibility of the in-service PPE with weapons and equipment as being acceptable – See Table 6**Error! Reference source not found.**. The compatibility acceptability of PPE with weapons and equipment varied between vehicle position and item. The Driver and CC/ Loader/ Gunner positions did not have any compatibility issues with weapon and equipment. Over 80% of the Drivers and the CC/ Loader/ Gunner positions rated the weapon and equipment compatibility as overall acceptable. Conversely only 50% of the Air Sentries believed the PPE was compatible with weapons and equipment.

Table 6: Weapon and Equipment Compatibility Percentage Acceptance Results

Weapon and Equipment Compatibility	Air Sentry	Driver	CC/ Loader/ Gunner	Overall
	Percentage of ≥ 4, Borderline (n)	Percentage of ≥ 4, Borderline (n)	Percentage of ≥ 4, borderline (n)	Percentage of ≥ 4, borderline (n)
.50 cal machine gun	100% (5)	100% (5)	67% (6)	88% (16)
C7-A1 Rifle	67% (6)	80% (10)	100% (9)	84% (25)
Flashbangs	50% (4)	100% (5)	88% (8)	83% (17)
Smoke grenades	25% (4)	100% (5)	100% (9)	83% (18)
Frag grenades	40% (5)	100% (7)	100% (10)	86% (22)
M72s	75% (4)	100% (4)	89% (9)	88% (17)
40mm	40% (5)	100% (4)	75% (8)	71% (17)
Slings	100% (4)	60% (10)	78% (9)	74% (23)
Night vision goggles	80% (5)	75% (8)	78% (9)	77% (22)
Binoculars	75% (4)	100% (8)	89% (9)	91% (21)
Radios - 521	50% (4)	86% (7)	75% (8)	74% (19)
- 522	60% (5)	86% (7)	89% (9)	81% (21)
- 117	75% (4)	86% (7)	89% (9)	85% (20)
- Overall	40% (5)	86% (7)	100% (10)	82% (22)
C6	60% (5)	100% (7)	89% (9)	86% (21)
9mm Pistol	20% (5)	88% (8)	89% (10)	74% (23)
Overall clothing compatibility	50% (6)	91% (11)	89% (9)	81% (26)

The level of compatibility satisfaction varied between crew position and item. The results indicate that generally weapons and equipment compatibility was rated as being acceptable for both the Driver and CC/ Loader/ Gunner positions. On the other hand, Air Sentries rated most of weapons and equipment compatibility as reasonably unacceptable to barely unacceptable. The average acceptability ratings for seven clothing compatibility and overall compatibility acceptability rating with standard deviation values are presented in Table 7.

Table 7: Weapon and Equipment Compatibility Acceptability Ratings

Weapon and Equipment Compatibility	Air Sentry	Driver	CC/ Loader/ Gunner
	Mean ±S.D.(N)	Mean ±S.D.(N)	Mean ±S.D.(N)
.50 cal machine gun	5.6 ± 1.3 (5)	5.8 ± 0.8 (5)	4.5 ± 2.1 (6)
C7-A1 Rifle	4.0 ± 1.3 (5)	4.9 ± 1.7 (10)	5.4 ± 1.0 (9)
Flashbangs	3.3 ± 1.7 (6)	6.0 ± 1.0 (5)	4.8 ± 1.0 (8)
Smoke grenades	2.5 ± 1.9 (4)	5.8 ± 1.1 (5)	5.1 ± 0.8 (9)
Frag grenades	3.2 ± 1.5 (4)	6.1 ± 0.9 (7)	5.1 ± 0.7 (10)
M72s	4.5 ± 1.3 (5)	6.0 ± 0.8 (4)	5.2 ± 1.2 (9)
40mm	3.2 ± 1.8 (4)	6.0 ± 0.8 (4)	4.1 ± 1.6 (8)
Slings	5.3 ± 1.0 (4)	4.3 ± 2.3 (10)	5.1 ± 1.4 (9)
Night vision goggles	4.2 ± 2.2 (4))	4.8 ± 1.7 (8)	4.7 ± 1.6 (9)
Binoculars	4.8 ± 1.3 (4)	5.9 ± 1.0 (8)	5.3 ± 1.2 (9)
Radios - 521	3.3 ± 1.0 (4)	4.7 ± 1.5 (7)	4.4 ± 1.7 (8)
- 522	3.8 ± 1.7 (5)	4.6 ± 1.4 (7)	5.1 ± 1.2 (9)
- 117	4.0 ± 0.8 (5)	4.9 ± 1.5 (7)	5.1 ± 1.2 (9)
- Overall	3.4 ± 1.1 (5)	4.6 ± 1.4 (7)	5.1 ± 0.6 (10)
C6	3.8 ± 2.2 (5)	5.7 ± 0.8 (7)	5.1 ± 1.2 (9)
9mm Pistol	2.2 ± 1.6 (5)	5.0 ± 1.3 (8)	4.9 ± 1.9 (10)
Overall clothing compatibility	3.8 ± 1.0 (6)	5.0 ± 1.4 (11)	5.2 ± 1.0 (9)

An analysis of Air Sentry complaints suggests that PPE compatibility problems may have been more due to compatibility issues with the tactical vest's load carriage properties and its movement, with respect to, fragmentation vest than the PPE system being investigated. Caution is also recommended when interpreting these results due to the relatively low sample size.

Overall the results suggest that, in general, the compatibility of the in-service PPE with weapons and equipment is acceptable.

4.3.2.3 Mounted Crewman Task Compatibility

Participants were asked to rate the acceptability of the in-service PPE for compatibility with mounted crew position tasks. Please note a number of tasks were unique for each position.

Air Sentry Tasks:

Overall, approximately 67% of the Air Sentry participants rated the compatibility of the in-service PPE with air sentry tasks as being acceptable. Except for filling magazines, changing ammo boxes for the C9 and C6 (33% acceptance) the Air Sentry participants rated compatibility at least at 50% for all other tasks; the level of task compatibility acceptance (rating scores) varied by Air Sentry task – see Table 8. Caution is recommended when interpreting these results due to the small sample size.

Table 8: Air Sentry Mounted Task Acceptability Ratings Results

Air Sentry Mounted Crewman Tasks Compatibility	Percentage accep table (≥ 4)	Mean rating ±S.D.
Donning PPE (n=6)	83%	4.5 ± 1.4
Doffing PPE (n=6)	83%	4.7 ± 1.6
Scanning/ covering arcs (n=6)	100%	4.8 ± 0.8
Changing mags, ammo boxes for C6/ ammo for C9 (n=6)	33%	2.8 ± 1.5
Firing M72s and 40 mms/ throwing grenades (n=5)	60%	3.4 ± 1.8
Being extracted internally/ externally (n=5)	80%	3.8 ± 0.4
Helping to extract participants from vehicles (n=6)	50%	3.5 ± 1.5
Roles after vehicle in convoy is hit from the side by a vehicle (n=6)	67%	3.3 ± 1.5
Providing first aid, within vehicle, to participants injured by IED (n=6)	50%	2.8 ± 1.7
Providing self aid, within vehicle, after impact with IED (n=6)	50%	2.8 ± 1.7
Waving off approaching persons/ vehicles (n=6)	100%	5.0 ± 0.9
Scanning high sides (n=6)	83%	4.8 ± 1.2
Scanning for IEDs in highly concentrated areas (ex. Trash build up areas) (n=6)	83%	4.8 ± 1.2
Normal access/ egress (n=6)	83%	4.3 ± 1.4
Emergency access/ egress (n=6)	83%	3.8 ± 1.0
Closing family hatches (n=6)	83%	4.2 ± 0.8
Visual scan of 5m (n=5)	80%	4.8 ± 1.9
Physical scan of 25m (n=6)	83%	5.0 ± 1.3
Overall crewman task compatibility (n=6)	67%	3.8 ± 1.9

The results suggest that improvements could be required to improve the compatibility of the in-service PPE with Air Sentry tasks.

Driver Tasks:

Overall approximately 90% of the Driver participants rated the compatibility of the in-service PPE with driving tasks as being acceptable. The level of task compatibility acceptance (rating scores) varied by Driver task – see Table 9. Overall the compatibility of the in-service PPE with Driver tasks was Borderline to barely Acceptable (4.7). Shading identifies areas that received below borderline scores for the selected topic.

Table 9: Driver Mounted Task Acceptability Ratings Results

Driver Mounted Crewman Tasks Compatibility	Percentage Acceptable (≥ 4)	Mean ±S.D.
Donning PPE (N=10)	90%	5.3 ± 1.2
Doffing PPE (N=10)	90%	5.3 ± 1.2
Control of vehicle (steering, braking, reaching) (N=11)	82%	4.6 ± 1.0
Scanning/ covering arcs (N=11)	82%	5.0 ± 1.4
Being extracted internally/ externally (N=10)	80%	4.3 ± 1.2
Helping to extract participants from vehicles (N=10)	80%	4.5 ± 1.4
Providing first aid, within vehicle, to participants injured by IED (N=10)	60%	3.9 ± 1.4
Providing self aid, within vehicle, after impact with IED (N=10)	60%	3.8 ± 1.5
Scanning for IEDs in highly concentrated areas (ex. Trash build up areas) (N=10)	70%	4.5 ± 1.6
Normal access/ egress (N=10)	100%	4.8 ± 0.8
Emergency access/ egress (N=11)	64%	4.2 ± 1.3
Visual scan of 5m (N=11)	100%	5.5 ± 1.0
Physical scan of 25m (N=10)	100%	5.5 ± 1.1
Overall crewman task compatibility (N=10)	90%	4.7 ± 1.2

The results suggest that few improvements could be required to improve the compatibility of the in-service PPE with Driver tasks. A common response by the participants as to why there are problems with providing first aid is the difficulty in removing the tactical vest from the soldier – See Annex C.

CC/Gunner and Loader Tasks:

Overall approximately 82% of the CC, Gunner and Loader participants rated the compatibility of the in-service PPE with their vehicle tasks as being acceptable. The level of task compatibility acceptance (rating scores) varied by crew position task – see Table 10. Notable compatibility issues were identified with use of the pintle-mounted C6 machinegun; only 22% of the participants rated this compatibility issue as being acceptable. The participants rated the compatibility of the in-service PPE and pintle-mounted engagement task as being Barely Unacceptable (3.0).

Table 10: CC/ Gunner/ Loader Mounted Crewman Task Acceptability Ratings Results

CC / Gunner / Loader Mounted Crewman Tasks Compatibility	Percentage Acceptable (≥ 4)	Mean ±S.D.
Donning PPE (N=11)	91%	4.9 ± 1.5
Doffing PPE (N=11)	91%	4.9 ± 1.5
Scanning/ covering arcs (N=10)	80%	4.8 ± 1.2
Waving off approaching persons/ vehicles (N=9)	89%	5.2 ± 1.2
Scanning high sides (N=9)	67%	4.9 ± 1.5
Scanning for IEDs in highly concentrated areas (ex. Trash build up areas) (N=9)	78%	5.1 ± 1.6
Normal access/ egress (N=10)	80%	4.7 ± 1.3
Emergency access/ egress (N=10)	80%	4.3 ± 1.2
Acquiring Targets (N=10)	90%	5.4 ± 1.5
Engagement of targets using pintle mount: at extremes (¼ - ½ right/ left) (N=9)	22%	3.0 ± 1.6
Accessing personal weapons if M6 fails. (N=10)	80%	4.8 ± 1.3
Being extracted internally/ externally (N=11)	55%	3.9 ± 1.4
Reloading weapons/ handling stoppages (N=10)	80%	4.8 ± 1.6
Reloading mags/ other ammo (N=11)	91%	5.0 ± 1.0
Exchanging ammo between participants (N=10)	80%	4.6 ± 1.3
Extracting mounted participants internally/ externally (N=11)	64%	4.2 ± 1.5
Overall crewman task compatibility (N=11)	82%	4.5 ± 1.1

The BTA identified a number of concerns with the current design of the pintle-mounted C6 machineguns found on many of the in-service vehicles. While the design may be acceptable for the engagement of low flying aircraft and helicopters, the system is not compatible with the engagement of close-in ground targets. Compatibility issues with in-service PPE and pintle-mounted machinegun tasks will not be addressed to modifications of the PPE as soldiers did not indicate that the problem is associated with their current PPE.

4.3.2.4 Dismounted Crewman Task Compatibility

Participants were asked to rate the acceptability of the in-service PPE for compatibility with Dismounted Crew position tasks.

Overall approximately 84% of the participants rated the compatibility of the in-service PPE with Dismounted Soldier tasks as being acceptable. Specific concerns were raised by Air Sentries with the compatibility of the in-service PPE with carrying assault loads and its compatibility with MOUT manoeuvre – see Table 11. Concerns were also raised by CC/Gunners and Loaders with the compatibility of the in-service PPE with vehicle recovery tasks (changing tires).

Table 11: Dismounted Crewman Tasks- Percentage Acceptance Results

Dismounted Crewmen Tasks	Air Sentry	Driver	CC/Gunner /Loader	Overall
	Percentage acceptable (≥ 4)	Percentage acceptable (≥ 4)	Percentage acceptable (≥ 4)	Percentage acceptable (≥ 4)
Long distance walking	83% (6)	67% (9)	60% (10)	68% (25)
Securing areas	67% (6)	89% (9)	91% (11)	85% (26)
Firing in kneeling position	50% (6)	89% (9)	82% (11)	77% (26)
Toss stun grenades, smoke grenades, Flashbangs	80% (5)	89% (9)	91% (11)	88% (25)
Attaching tow cables for quick tow	60% (5)	89% (9)	91% (11)	84% (25)
Changing vehicle tires	50% (6)	100% (9)	38% (8)	65% (23)
Vehicle maintenance tasks	50% (6)	89% (9)	82% (11)	77% (26)
Securing load on MLVW and HLVW	80% (5)	89% (9)	82% (11)	84% (25)
Performing a rolling replenishment	80% (5)	100% (8)	91% (11)	92% (24)
Carrying full kit / carrying assault order	40% (5)	78% (9)	78% (9)	74% (23)
Room Search	60% (5)	100% (7)	100% (8)	90% (20)
Crawling	60% (5)	78% (9)	67% (9)	70% (23)
Manoeuvring through small 'Yoda' doors	40% (5)	80% (5)	67% (9)	63% (19)
Combat Shooting	80% (5)	88% (8)	80% (10)	83% (23)
Providing first aid to other participants	67% (6)	88% (8)	90% (10)	84% (24)
Receiving first aid from other participants	60% (5)	75% (8)	60% (10)	65% (23)
Carrying injured participants over large distances	60% (5)	75% (8)	70% (10)	70% (23)
Overall compatibility	67% (6)	86% (7)	91% (11)	84% (24)

The level of task compatibility acceptance (rating scores) varied by crew position task – see Table 12. Air Sentries reported a lower level of dismounted task acceptance with in-service PPE than the other crew positions.

Table 12: Overall Dismounted Crewman Task Ratings Results

Dismounted Crewman Tasks	Air Sentry Mean ±S.D.(N)	Driver Mean ±S.D.(N)	CC/Gunner /Loader Mean ±S.D.(N)
Long distance walking	4.3 ± 1.4 (6)	4.4 ± 1.2 (9)	4.1 ± 1.4 (10)
Securing areas	3.8 ± 1.9 (6)	5.3 ± 1.1 (9)	5.1 ± 0.9 (11)
Firing in kneeling position	3.5 ± 1.9 (6)	5.1 ± 1.2 (9)	4.5 ± 1.1 (11)
Toss stun grenades, smoke grenades, Flashbangs	4.2 ± 1.5 (5)	5.0 ± 0.9 (9)	5.0 ± 1.2 (11)
Attaching tow cables for quick tow	3.8 ± 1.8 (5)	4.9 ± 0.9 (9)	4.8 ± 1.3 (11)
Changing vehicle tires	3.3 ± 2.0 (6)	5.0 ± 0.7 (9)	3.8 ± 1.4 (8)
Vehicle maintenance tasks	3.3 ± 2.0 (6)	4.6 ± 1.0 (9)	4.5 ± 1.0 (11)
Securing load on MLVW and HLVW	4.2 ± 1.5 (5)	4.8 ± 1.0 (9)	4.5 ± 1.3 (11)
Performing a rolling replenishment	4.2 ± 1.5 (5)	5.1 ± 0.6 (8)	5.0 ± 1.3 (11)
Carrying full kit / carrying assault order	3.4 ± 2.1 (5)	4.6 ± 1.3 (9)	4.7 ± 1.1 (9)
Room Search	3.8 ± 1.8 (5)	4.6 ± 0.5 (7)	5.1 ± 1.0 (8)
Crawling	3.6 ± 1.5 (5)	4.7 ± 1.1 (9)	4.0 ± 1.3 (9)
Manoeuvring through small 'Yoda' doors	3.0 ± 1.6 (5)	4.2 ± 0.8 (5)	4.0 ± 1.2 (9)
Combat Shooting	4.4 ± 1.5 (5)	5.1 ± 1.1 (8)	4.7 ± 1.6 (10)
Providing first aid to other participants	4.0 ± 1.7 (6)	4.9 ± 1.0 (8)	4.7 ± 1.3 (10)
Receiving first aid from other participants	3.6 ± 2.1 (5)	4.1 ± 1.2 (8)	3.8 ± 1.8 (10)
Carrying injured participants over large distances	3.8 ± 1.8 (5)	4.0 ± 1.7 (8)	4.5 ± 1.7 (10)
Overall compatibility	4.2 ± 1.8 (6)	4.9 ± 1.1 (7)	4.6 ± 1.1 (11)

Although a significant majority (84%) of the participants rated the compatibility of the in-service PPE with dismounted tasks as being acceptable, concerns were raised with the level of compatibility. An analysis of Air Sentry concerns suggests that PPE compatibility problems may have been more due to compatibility issues with the tactical vest than the PPE system being investigated. Caution is recommended when interpreting these results due to the relatively low sample size.

4.3.3 Physical Discomfort

Participants were asked to assess the in-service PPE for physical discomfort using a 5-point discomfort scale. The scale includes verbal anchors as follows: with neutral at one, noticeable discomfort at three and extreme pain at five. Participants were asked to identify regions of discomfort and the level of discomfort using body maps – see Figure 97. Additionally each participant completed a physical comfort questionnaire that examined breathing constriction, pressure points, and chaffing. The comfort rating was given on a scale of 1 to 7, with completely unacceptable at one, borderline at four, and completely acceptable at seven.

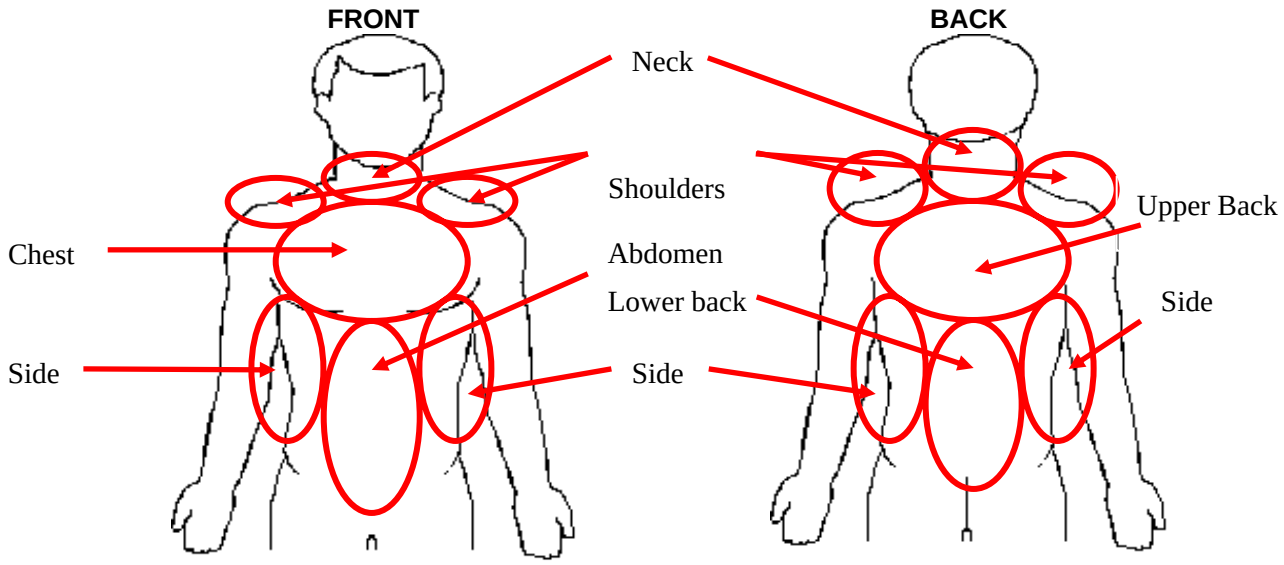

Figure 97: Physical Discomfort Zones

Using the standard 5-point discomfort rating scale, 89% (25 of 28) of participants reported some type of physical discomfort (slight discomfort >1) in one or more body zones with the in-service PPE. Thirty-two percent (9 of 28) of the participants rated pain (>4) on one or more zones of the torso. Table 13 details the percentage of participants who indicated slight discomfort and pain when wearing the in-service PPE. The body region that received the highest complaints was the front and back of the neck. Approximately 50% of the participants experienced discomfort with the PPE's neck design and or fit. Shading indicates areas that received a discomfort rating by at least >20% of the participants.

Table 13: Physical Discomfort Acceptance Results

Physical Discomfort Zones	Users indicating discomfort > 1 ,Slight physical discomfort (≥ 4, pain)
Front	
Neck	50% (7%)
Shoulder	25% (7%)
Chest	4% (0%)
Abdomen	14% (0%)
Side	14% (4%)
Back	
Neck	39% (11%)
Shoulder	29% (11%)
Upper Back	14% (7%)
Lower Back	32% (14%)
Sides	14% (4%)

Scale: **1-**Neutral **2-** Slight Discomfort **3-** Noticeable Discomfort **4-** Pain **5-** Extreme Pain

Using the standard seven point rating scale of acceptability, the participants indicated "borderline" acceptability with the in-service PPE for all five physical comfort aspects. The participants average acceptability ratings for five physical comfort aspects with standard deviation values are presented in Table 14**Error! Reference source not found.**.

Table 14: Ratings of Physical Discomfort Based on the 7 Point Scale

Overall aspects of physical Comfort:	Acceptability Rating
	Mean ± S.D.
Breathing Constriction (n=28)	4.3 ± 1.8
Pressure points while stationary (n=28)	4.5 ± 1.6
Pressure points while moving (n=27)	4.9 ± 1.4
Chaffing (n=27)	4.2 ± 1.8
Overall physical comfort (n=24)	4.7 ± 1.3

A number of comments were received on physical discomfort. These comments are summarized below in Table 15. The most commented area of physical discomfort was with neck chaffing.

Table 15: Physical Discomfort Comments

Comment Areas and Examples	n
Issues with chaffing neck area: • Chaffing slightly at neck • Slight chaffing around the neck • Chaffs my neck	6
Issues with chaffing underarms area: • Chaffing near underarms stationary and while moving • Chaffing underarms near biceps	2
Issues with breathing: • Breathing constrictive… under contact it actually kicks in • Vest needs more breathing room under intense combat	2

Overall, the study participants considered the in-service PPE Borderline to Barely Acceptable for prolonged wear. A large number of participants (89%) noted discomfort while wearing the in-service PPE. The majority of participant's complaints were related to the fragmentation vest's neck design. The results suggest that improvements should be made to the fragmentation vest collar design.

4.3.4 Thermal Discomfort

Participants were asked to assess the in-service PPE for thermal discomfort using a 5-point thermal discomfort scale. The scale includes verbal anchors as follows: neutral at one, noticeably warm at three and very hot at five. Participants were asked to identify 18 body regions of thermal discomfort and the level of discomfort using body maps – see Figure 98. In addition to the body mapping of thermal discomfort, participants also rated thermal comfort acceptability for hot spots, ventilation and overall comfort. Additionally each participant completed a thermal comfort

questionnaire that examined ventilation, hotspots and overall thermal comfort. The thermal comfort rating was given on a scale of 1 to 7, with completely unacceptable at one, borderline at four, and completely acceptable at seven.

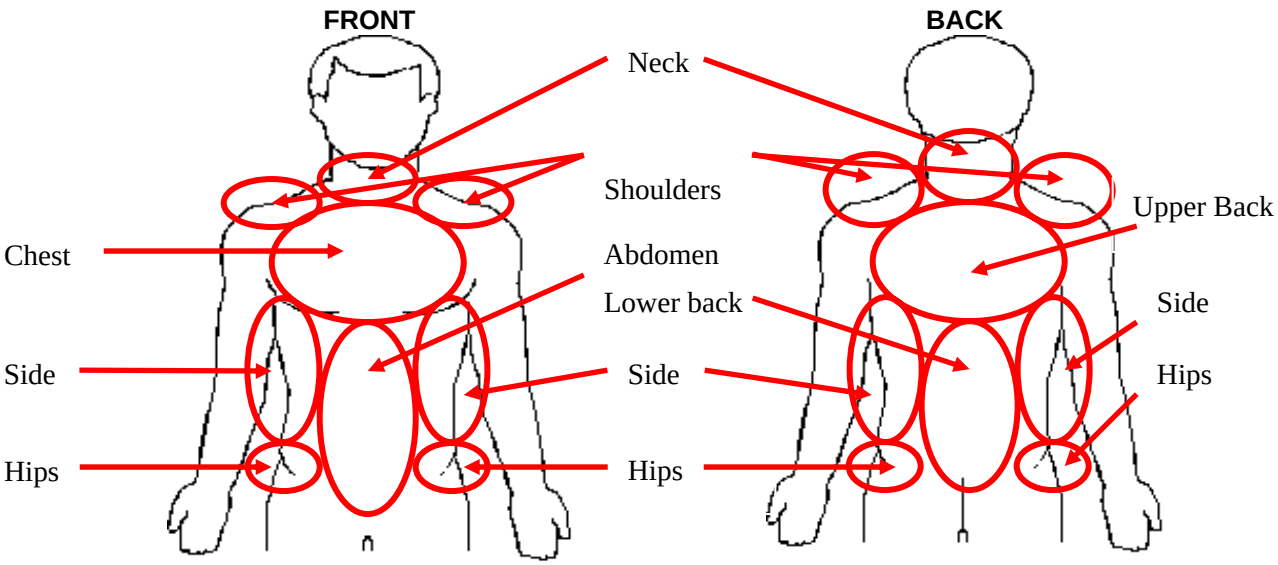

Figure 98: Thermal Discomfort Zones

Using the standard five point rating scale of thermal discomfort, 93% (26 of 28) of participants rated some type of thermal discomfort (slightly warm or more discomfort) in one or more torso zones with the in-service PPE. Seventy-nine percent (22 of 28) of the participants rated "hot" or "very hot" on two or more zones of the torso. Central torso chest (79%), abdomen (57%), upper back (86%) and lower back (71%) areas had the highest levels of thermal discomfort, with respect to the in service PPE. The results below indicate the percentage of participants rating the 18 locations greater than 1 ("slightly warm") and greater than or equal to 4 ("hot") – see Table 16**Error! Reference source not found.**.

Table 16: Thermal Discomfort Acceptance Results

Thermal Discomfort Zones	Users indicating discomfort >1 ,"Slightly warm"(≥ 4, "hot")
Front	
Neck	11% (11%)
Shoulder	18% (11%)
Chest	79% (68%)
Abdomen	57% (54%)
Side	32% (25%)
Hips	18% (14%)
Back	
Neck	11% (11%)
Shoulder	18% (11%)
Upper Back	86% (71%)
Lower Back	71% (64%)
Sides	29% (25%)
Hips	18% (14%)

Scale:

1-Neutral

2- Slightly Warm

3- Noticeably Warm

4- Hot

5- Very Hot

In addition to the body mapping of thermal discomfort, participants also rated thermal comfort acceptability for hot spots, ventilation and overall comfort. Using the standard seven point rating scale, the participants indicated "Borderline to Barely Unacceptable" levels of thermal acceptance – see Table 17.

Table 17: Ratings of the Thermal Comfort on a 7 Point Scale

Overall aspects of thermal comfort	Rating
	Mean ± S.D.
Hot spots (n=28)	3.7 ± 1.7
Ventilation (n=28)	3.1 ± 1.8
Overall thermal comfort (n=28)	3.6 ± 1.6

A number of comments were received on thermal discomfort. These comments are summarized below in Table 18. The most commented areas of thermal discomfort were the inability to ventilate and the hot Afghanistan environment.

Table 18: Thermal Discomfort Comments

Comment Areas and Examples	n
Issues with ventilation: • Ventilation not breathable • There is no ventilation about the PPE • Too tight to ventilate	5
Issues with hot environment: • Its 50 C over there, its going to be hot • Specific only to Afghanistan due to hot climate	3

The participants evaluated the in-service PPE for use in the very hot dry environments of the Afghanistan operational context. The majority of participants indicated excessive thermal discomfort ("hot" and "very hot"); given the extreme operating environment in Afghanistan and the impermeable nature of ballistic protection these results were not unexpected. Even though individuals recorded excessive levels of regional thermal discomfort, their overall ratings of thermal discomfort were just "Borderline" to "Barely Unacceptable". These results could be interpreted by some that the in-service fragmentation vest is in fact a successful design. The results do suggest that improvements in PPE ventilation could improve user satisfaction with the in-service fragmentation vest.

4.3.5 Range of Motion

Participants were asked to assess the acceptability of the in-service PPE for ranges of motion using the standard 7-point scale. Participants also provided comments on the interference between the in-service PPE and free limb and body movement.

Greater than 70% (20 of 28) of the participants rated shoulder, neck, trunk, knee, hip, and wrist range of motion with PPE as being acceptable. The results below indicate the percentage of participants rating the seven range of motion areas greater than or equal to 4 – see Table 19**Error! Reference source not found.**.

Table 19: Range of Motion Acceptability Results

Range of motion area	Percentage acceptable (≥ 4)	Rating
Shoulder		Mean ± S.D.
Flexion (n=27)	96%	5.1 ± 1.1
Extension (n=27)	89%	5.0 ± 1.1
Abduction (n=27)	85%	4.8 ± 1.1
Adduction (n=27)	96%	4.9 ± 1.0
Overall Shoulder Motion (n=27)	93%	5.0 ± 1.1
Elbow		
Flexion (n=24)	100%	6.3 ± 0.8
Extension (n=24)	100%	6.3 ± 0.8
Overall Elbow Motion (n=25)	100%	6.2 ± 0.8
Neck		
Flexion (n=28)	89%	4.9 ± 1.5
Extension (n=28)	86%	4.8 ± 1.6
Rotation (n=28)	71%	4.7 ± 1.7
Overall Neck Motion (n=27)	85%	4.7 ± 1.6
Trunk		
Flexion (n=26)	85%	4.9 ± 1.4
Extension (n=26)	88%	5.1 ± 1.3
Lateral bending (n=26)	85%	4.5 ± 1.3
Rotation (n=26)	88%	4.9 ± 1.3
Overall Neck Motion (n=25)	88%	4.8 ± 1.3
Knee		
Flexion (n=24)	100%	6.0 ± 0.9
Extension (n=24)	100%	6.0 ± 0.9
Overall Knee Motion (n=23)	100%	6.0 ± 0.9
Hip		
Flexion (n=26)	88%	5.5 ± 1.4
Extension (n=26)	88%	5.6 ± 1.3
Abduction (n=26)	88%	5.6 ± 1.3
Adduction (n=26)	85%	5.5 ± 1.4
Overall Hip Motion (n=25)	88%	5.5 ± 1.4
Wrist		
Flexion (n=24)	96%	6.3 ± 1.2
Extension (n=24)	96%	6.3 ± 1.2
Overall Wrist Motion (n=24)	96%	6.2 ± 1.1

The participants rated all ranges of motion with the in-service PPE as being acceptable. The neck and trunk areas had the least acceptability, receiving a "Borderline" in acceptance. The shoulders and hip areas were rated as being "Barely Acceptable". Three areas (elbow, knee and wrist) were rated as "Reasonably Acceptable" with respect to range of motion.

A number of comments were received on freedom of movement and are given below in Table 20. Although not evident in the range of motion measures, a large number of participants commented that the shoulder pads interfered with their arm movement. A quick investigation revealed that when judged in absolute angles of movement, the soldiers could achieve close to unencumbered

ranges of motion with the in-service PPE but they had to do so by fighting increasing levels of resistance from the vest. Similarly while a number of participants reported that the collar design restricted head movement, the soldiers could also achieve unencumbered ranges of motion with the in-service PPE. The collar design of the in-service PPE did appear to rub against the neck during head rotation motions.

Table 20: Range of Motion Comments

COMMENT AREAS AND EXAMPLES	N
ISSUES WITH SHOULDER: • SHOULDER MOTION ARE LIMITED WHEN IT COMES TO DRIVING • SHOULDER MOTION WITHOUT PADS (N=7) • SHOULDER CAPS RESTRAINED MOVEMENT	10
ISSUES WITH NECK RANGE OF MOTION: • NECK MOTION WITHOUT NECK PIECE (N=2) • NECK RESTRICTIVE • NECK SEEMS CONSTRICTIVE…	5

While the participants considered the effects of the in-service PPE on range of motion as being acceptable, concerns were raised with the shoulder cap and collar design. From a strict range of motion perspective the in-service PPE design could allow adequate ranges of motion. Ranges of shoulder motion and neck rotation motion were affected by the close fitting design of the in-service PPE. The results do suggest that changes to the shoulder cap and collar design of the in-service PPE could improve perceived ranges of motion and physical comfort.

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5 Discussion and Recommendations

The aim of this project is to conduct a BTA for the mounted crewman in various vehicles in support of Phase I of a PPE protection versus performance trade-off analysis in part of the C-IED project. The goal of this study was threefold:

1) Develop operational scenarios to investigate vehicle operations;
2) Conduct a task analysis of vehicle crew, especially the exposed crew positions; and
3) Indicate the likely ballistic threats in each crew station, identifying specific crew stations and tasks that could negatively be affected by the current and additional PPE.

5.1 Operational Scenarios

As a result of the validation trial conducted from 1 – 2 February 2007, four operational scenarios were developed that encompassed the majority of tasks encountered by mounted crewmen in Afghanistan. The scenarios included a quick reaction force scenario, an urban vehicle breakdown scenario, an ambush scenario and a VBIED scenario. The scenarios included a number of elements that addressed typical operational and combat support tasks and activities. The validity of the operational scenarios was confirmed by the trial participants and all the trial participants had experienced or witnessed the effects of IED attacks. Concern was raised by some participants that the study overly focussed on mounted tasks and limited discussion to the 5 and 20 m zone. A more comprehensive survey of the compatibility of the current in-service PPE with dismounted soldier tasks should be undertaken. Infantry participants believed that mounted tasks flowed immediately into dismounted manoeuvres. They strongly believed that any new PPE design must allow the mounted soldier to seamlessly transition into ground combat.

The operational scenarios included out of contact mounted crew tasks in the countryside and in built-up areas. Crew exposure changes when vehicles move into built-up areas. Rules of engagement may limit the use of 25mm and 105mm canon forcing CC, Gunners and Loaders to use secondary roof mounted machineguns and personal weapons. Crews in built-up areas are typically more exposed than when in the countryside. This exposure has been offset by the apparent reluctance (until now) of enemy combatants to use IEDs that could endanger the nearby civilian population. Crews in built-up areas wave approaching vehicles and locals to stop from approaching too close. Participants reported stopping dismounted suicide bombers from approaching convoys after a vehicle breakdown in a built-up area. If a wave-off is not sufficient higher levels of warnings and force are utilized.

The operational scenarios also included vignettes where vehicle crews engage targets with secondary and personal weapons. In addition to driving through small arms ambushes, IED ambushes have included small arms attacks after the main explosion was initiated. These scenarios could see vehicle crews engaging dismounted targets. Participants reported engagements where crews engaged multiple targets simultaneously.

Although the VBIED scenario was included for discussion, the participants stated that there was little crews could do to stop an attack. VBIED attacks to date have included suicide vehicle bombers quickly crossing roads from the opposite side or vehicles approaching from hidden ground. The participants reported that crews do not have time to engage targets or even drop down

into cover. Participants reported an early incident where a Bison crew did drop after a vehicle rammed them and the bomb did not explode. Unfortunately the bomber backed up and rammed the vehicle again successfully setting off the bomb. The incident suggests that dropping down may still have lethal consequences, if there is a detonation that overmatches the vehicle's hull.

5.2 Behavioural Task Analysis

A BTA was completed for the G-wagon, MLVW, HLVW, Bison, Coyote, TLAV, Leopard C2 and LAV III. The result of the BTA and associated crew exposures are detailed below.

5.2.1 G-Wagon

Not all in-service G-Wagons have the Armour Protection System (APS) attached or come equipped with hatch guns or even armoured cupolas. The APS is designed to protect the crew compartment, provide NATO level 1 protection against small arms and protection against grenades and anti-personnel mines. Any G-Wagon out of the "wire" in Afghanistan will have the APS, so these recommendations are based on the G-Wagons used in theatre. G-Wagons with roof hatch machineguns are used as reconnaissance and convoy escort vehicles.

It was reported by participants that during a convoy, a two-person G-Wagon crew will rarely leave the vehicle. The presence of a hatch gunner will allow the CC more latitude to leave the vehicle. For the majority of mounted tasks the G-Wagon Driver and CC are protected by the APS. The hatch gunner will have similar protection for their lower body and may have some protection for their upper body if an armoured cupola is installed. There are however, gaps in armour coverage between the gun shield and the C6, and between the side armour gun shield and hatch door. The top of the hatch gunner's head is exposed above the cupola and gun shield armour. Hatch gunners who are not equipped with an armoured cupola are exposed from the waist up. If the gunner has to engage close in targets, the gunner's body is further exposed.

While G-Wagon Drivers and CC do not undergo extreme ranges of motion while performing their typical tasks, hatch gunners do. Hatch gunners need to pull themselves up into the roof hatch and need to be able to rapidly rotate the ring mount and elevate or depress the C6 machinegun. Adding PPE to the face, neck, arms, or legs may hinder ranges of motion for the Driver, CC and gunner.

Gunner's manning G-Wagon's without an armoured cupola could benefit from additional PPE. All G-Wagon gunners may benefit from the provision of ballistic visors. G-wagon crews could benefit from the provision of additional PPE as long as it does not interfere with normal crew tasks.

5.2.2 MLVW

While the MLVW was included in this BTA, the participants reported that the vehicle does not leave base camp confines. MLVWs can be equipped with an ad hoc add-on armour package consisting of ballistic blankets (covering the floor and seats), a bullet-proof windshield, ballistic windows/ kevlar plate for the upper door, as well as add-on armour plate for the lower door portion and for the upper part of the rear of the cab.

For MLVWs not equipped with the added armour protection package, the Driver and CC are fully exposed to the effects of IED blasts.

The Driver of the MLVW needs full range of shoulder, trunk and hip motion to perform tasks effectively and efficiently. CCs do not undergo extreme ranges of motion.

Adding PPE to the face, neck, arms, or legs may hinder ranges of motion for the Driver and MLVW CC. All unarmoured MLVW crews will benefit from the provision of additional PPE. Easily added ballistic protection could entail side plates and ballistic visors. Any protection added to the arms and legs cannot restrain or decrease the Drivers range of motion. Decisions on adding additional torso protection must take into consideration that Drivers perform many tasks outside of normal driving tasks. It is typically a tight squeeze into the Drivers position of the MLVW so any additional torso PPE will make this fit even tighter. MLVW crews could benefit from the provision of additional PPE as long as it does not interfere with normal crew tasks.

5.2.3 HLVW

The HLVW does come with an added armour protection package and while the HLVW does have a roof hatch, the participants reported that roof hatches were being used for air conditioning units and not hatch guns. Therefore, the susceptibility of the two person crew to the effects from an IED blast depends on whether the HLVW is equipped with the added protection or not.

Drivers and CCs of HLVWs that do not come with the added armour protection package are fully susceptible to the effects of IED blasts. With the added armour protection package the crew's susceptibility to effects from IED blasts is reduced.

The Driver of the HLVW needs full range of shoulder, trunk and hip motion to perform tasks effectively and efficiently. HLVW CCs do not require the same freedom of movement.

Adding PPE to the face, neck, arms, or legs may hinder ranges of motion for the Driver and HLVW CC. Therefore, any additional ballistic protection to the current in-service PPE must take into consideration the many different crew tasks that need to be performed. Like the MLVW, HLVW Drivers typically squeeze into the Drivers position of the HLVW so any additional torso PPE will make this fit even tighter and may even prevent some soldiers from getting into the right position. Drivers require a significant amount of arm and leg movement and any additional ballistic PPE on the arms or legs cannot decrease normal range of motion and any added protection to the torso must do the same.

HLVW crews could benefit from the provision of additional PPE as long as it does not interfere with normal crew tasks. Possibilities may include side plates and ballistic visors. Any protection added to the arms and legs cannot restrain or decrease the Driver's range of motion.

5.2.4 TLAV

A large number of TLAV and M113A3 tracked light armoured vehicle variants are in the CF inventory. While some TLAV variants only have a CC and a Driver, others are equipped with Air Sentries. The TLAV used in this BTA only included a Driver and a CC (due to participant and vehicle availability). Some TLAVs are equipped with a turret, others a PWS or a simple pintle-mounted machinegun.

The level of crew exposure is TLAV variant and task dependent. All crew positions experienced some level of IED exposure. Crews typically operated in a hatches-out state. Their exposures were dependent on the mission or situation. For example, in suspicious territory the Driver would drive hatches down, thereby making him fully protected. Common exposures for the Driver are from the shoulders up leaving the face and neck exposed. CCs are typically exposed from the shoulders up. If the CC has to utilize a pintle-mounted machinegun they are exposed from the waist up. While this BTA study did not include Air Sentries, their duties and exposures are similar

to Air Sentries found in LAV IIIs. Air Sentries are also exposed from the chest up. When travelling in towns and cities TLAV CC and Air Sentries are exposed from the waist up.

TLAV crews need full range of motion to complete their tasks.

Additional PPE cannot hinder the ability of the Driver, CC and Air Sentry from performing essential tasks such as, engaging targets with their personal weapon or C6, and performing vehicle maintenance tasks. TLAVs equipped with turrets and PWS may not benefit as much as TLAVs not so equipped. CC and Air Sentries are typically more exposed than Drivers. All may benefit from additional PPE such as a visor and neck guard. Concerns were raised by TLAV crews with the current design of the fragmentation vest shoulder caps. Participants reported they do not wear them because they are cumbersome and often do not stay attached. Design changes to reduce the degree of snagging and retention problems could improve the rate of usage. For CCs using pintle-mounted machineguns their whole upper body (from the waist up, in some instances greater) is exposed when engaging targets with their C6. Additional PPE could be of benefit as long as the added protection does not hinder the CC from performing defensive fire tasks. TLAV Driver and Air Sentry positions could benefit from the provision of additional PPE as long as it does not interfere with their crew tasks.

The design of the TLAV pintle-mounted C6 machinegun is not fully compatible with the ground threats faced in Afghanistan. The current pintle-mount design forces CCs to be extremely exposed for close-in ground targets. Participants identified the need for a reduction in the pedestal height. Participants also noted that many C6 machingeuns used on vehicles are not equipped with spade grips. The use of spade grips will also reduce CC exposure.

5.2.5 Bison

The Bison is currently used in a number of variants for combat support duties. While the Bison always has a CC and Driver, some variants are equipped with family hatches and thus Air Sentries. The Bison used in this BTA was a vehicle recovery variant and therefore had only two crewmen, the CC and Driver.

The level of crew exposure is Bison variant and task dependent. All crew positions experienced moderate levels of IED exposure. Crews typically operated in a hatches-out state. The Driver has their whole head above the rim of the hatch in order to see through the episcopes while the CC sits a little higher than the Driver (usually nametag and above). The CC's whole upper body (from the waist up) is exposed when engaging targets with their C7 or C6. This leaves the CC very exposed to the effects from IED blasts for the majority of the time. Air Sentries, if so equipped are also exposed from the chest up. When travelling in towns and cities Bison CC and Air Sentries are exposed from the waist up, while the Driver is exposed from the shoulders up. The level of Bison crew exposures is dependent on the mission or situation.

Bison crews need full range of motion to complete their tasks.

The provision of additional ballistic protection needs to consider limited Bison CC and Driver hatch space. Additional PPE cannot hinder their accessibility to access and egress from hatches. Additional PPE also should not hinder a CC's ability to utilize the ring-mounted C6 machinegun. Any additional PPE to the arms and legs should not prohibit any Bison crew member from performing their combat duties. The Driver of the Bison may benefit from a ballistic visor, due to the fact that the majority of the time the Driver's head is always exposed. The visor should have anti-fog and scratch resistance so it does not impair with any of the driving duties. The CC and Air

Sentry may also benefit from the same ballistic visor, as well as, side plates and arm protection, provided that it does not decrease their ROM. The additional PPE cannot prevent the CC and Air Sentry from safely moving in and out of the hatch as the threat level changes.

The design of the Bison ring-mounted C6 machinegun is not fully compatible with the ground threats faced in Afghanistan. The current ring-mount design forces CCs to be extremely exposed for close-in ground targets. Participants identified the need to reduce the machinegun height if possible. As with the TLAV, some Bison's are not equipped with spade grips for their C6. Provision of spade grips should reduce CC exposure.

5.2.6 Leopard C2 Tank

A Squadron of Leopard C2 tanks have been deployed to Afghanistan. The Leopard C2 has a total of four crew positions.

Two crew positions are not exposed during mounted tasks (Gunner and Driver); while two crew positions have some exposure for most of the mounted tasks (CC and Loader). CC and Loaders typically operated in a hatches-out state. The level of CC and Loader exposure is mission and threat dependent. The exposure of these positions range from head up, looking over their episcopes to waist up in order to engage targets with personal weapon or to visually scan objects of interest. When travelling in towns and cities Leopard CC and Loaders are exposed from the waist up.

Even though the Gunner and Driver are not exposed during mounted tasks their needs need to be considered when selecting additional PPE. Both the Gunner and Driver work in very confined spaces and any additions to their current PPE suite may inhibit them getting into and out of their stations, as well as, increase their thermal discomfort. The Driver and Gunner also need to be able to successfully mount and dismount from the Leopard without being encumbered from any of the additional PPE. If the Leopard becomes disabled, the Driver will assume the role of the Loader. Therefore, any changes to the Drivers PPE must be compatible to the Loader's tasks. Any additional PPE should not inhibit the CC and Loader from moving in and out of the hatch easily and from accessing normal engagement with personal weapons position. All members of the crew mentioned that they did not wear their tactical vest due to heat and accessibility restrictions. Therefore, any additional PPE may not be worn due to those same reasons. The Leopard crew also spend considerable periods of time maintaining the tank so any additional PPE must allow the crew to perform these duties. It was also mentioned by the crew that in combat Leopard crews will switch position if there have been casualties, so any PPE must be acceptable to all Leopard crew positions.

Leopard crews need full range of motion to complete their tasks.

Due to the fact that CC and Loader are the primarily exposed crewmen for the majority of tasks they would be the only ones that would benefit from additional PPE. Possibilities include a ballistic visor since, for the most part it is only their head exposed. This visor cannot impair their normal tasks and interfere with their engagement practices. Side plates are another possibility but thermal comfort must be taken into consideration as the crew already do not wear their tactical vest due to heat. The Gunner and Driver are within the confines of the tank for the vast majority of their tasks so any additional PPE would increase their thermal load and possibly cause more impairment than improvement.

5.2.7 Coyote

The Coyote is currently used for reconnaissance and convoy escort tasks. The Coyote has four crew members: Driver, CC, Gunner and Surveillance Operator. When the Coyote is moving the Surveillance Operator acts as an Air Sentry.

All four crew positions are exposed to the effects of IED blasts. The Driver is exposed from the shoulders up when driving "hatches out". His head and neck are fully exposed. Similarly, the CC and Gunner's normal positions are hatches up with just their head's exposed. When travelling in towns and cities Coyote CC, Gunners and Air Sentries are exposed from the waist up. Rules of engagement may limit the use of the Coyote's 25mm canon, forcing the CC and Gunner to also rely on the pintle-mounted C6 and personal weapons. The design of the pintle-mounted machinegun is not optimal for the engagement of close-in targets. In some cases short Gunners or CCs have to stand literally out of the hatch to use the C6 against ground targets.

Coyote crews need full range of motion to complete their tasks. Any additional ballistic protection needs to consider that the Coyote's Driver, CC and Gunner have limited space within the hatch and that additional PPE cannot hinder their accessibility to access and egress from the hatch. Additional PPE cannot hinder the ability of crew from performing essential tasks such as, engaging targets with personal weapon or C6, and performing vehicle maintenance tasks.

The Driver of the Coyote may benefit from the provision of a ballistic visor and neck guard as the Driver's head is frequently exposed. Additional protection must not hinder the Drivers range of motion or visibility. The CC, Gunner and Air Sentry (Surveillance Operator) may also benefit from added PPE. As with the Driver, additional PPE must not decrease range of motion.

5.2.8 LAV III

The Light Armoured Vehicle (LAV III) is a fast, well armed, state of the art infantry section carrier. The LAV III has a dedicated vehicle crew of a Driver, CC and Gunner. In addition, the LAV III has a troop carrying compartment that can hold up to seven infantry section soldiers.

The LAV III has potentially 4 to 6 exposed soldiers: Driver, CC, Gunner and a number of Air Sentries. The level of crew exposure is task and threat dependent. CC, Gunner and Air Sentries experienced moderate levels of IED exposure. Crews typically operated in a hatches-out state. CCs are typically exposed from the shoulders up. When travelling in towns and cities LAV III CC, Gunners and Air Sentries are exposed from the chest up. Rules of engage may limit the use of the LAV's 25mm cannon, forcing the CC and Gunner to also rely on the pintle-mounted C6 and personal weapons. As with the Coyote, the design of the pintle-mounted machinegun is not optimal for the engagement of close-in targets. In some cases short CCs have to stand literally out of the hatch to use the C6 against ground targets. If the CC has to utilize a pintle-mounted machinegun, they are exposed from the waist up. When Gunner's operate hatches-up, they are also exposed from the chest up. If CC or Gunner's have to engage very close targets or wave off potential threats they will expose more of their bodies. Air Sentries are also exposed from the chest up. They will drive in hatches down configuration unless they are in an open and secure terrain.

LAV III crews need full range of motion to complete their tasks. Any additional ballistic protection needs to consider that LAV III CCs and Air Sentries typically dismount upon or shortly after enemy contact. Dismounted combat movement requires nearly full ranges of motion. The LAV's Driver, CC and Gunner have limited space within the hatch and that additional PPE cannot

hinder their accessibility to access and egress from the hatch. Additional PPE cannot hinder the ability of crew from performing essential tasks such as, engaging targets with personal weapon or C6, and performing vehicle maintenance tasks. Concerns were raised by LAV crews with the current design of the fragmentation vest shoulder caps. Participants reported they do not wear them because they frequently become undone and they snag slowing down movement through hatches. Design changes to reduce the degree of snagging and retention problems could improve the rate of shoulder cap usage.

Since the Driver is usually within his hatch, he experiences little exposure and it is suggested that the Driver may not require additional PPE. The CC, Gunner and Air Sentries on the other hand, experience much more exposure and additional PPE may be beneficial. As stated earlier, any additional PPE must not hinder LAV crews from the mounted and dismounted tasks. PPE such as ballistic visor (anti-fog and scratch resistant), throat guard, and upper limb protection may provide added protection with minimal task interference. Adding PPE armour such as full arm guards or leg guards may excessively hinder crew range of motion, and may be too hot to wear in Afghanistan.

The design of the LAV III pintle-mounted C6 machinegun is not fully compatible with the ground threats faced in Afghanistan. The pintle-mount design forces CCs to be extremely exposed for close-in ground targets. Participants identified the need to reduce the machinegun height if possible. As with the TLAV, some LAV's are not equipped with spade grips for their C6. Provision of spade grips should reduce CC exposure.

5.3 In-Service PPE Evaluation

While the previous section identified tasks that could negatively be affected by additional PPE, this section provides specific feedback on the current PPE design.

A PPE questionnaire was given to 28 soldiers that all had operational experience. The questionnaire divided the participants into three different sub-groups from Drivers, Air Sentries and CC / Driver / Loader. The participants completed the PPE questionnaire in the operational context of Afghanistan in terms of ballistic coverage, compatibility, physical discomfort, thermal discomfort and range of motion. The final area of each questionnaire section asked for comments from the participants that relate to acceptability of PPE. The number of Air Sentry participants was too small to draw definitive conclusions.

In general, the PPE questionnaire identified issues with the in-service PPE design with ballistic coverage acceptability. The results suggest that participants considered the existing ballistic protection coverage of the central torso zone, such as upper chest, upper back, abdomen and lower back was sufficient where as the side of torso, neck, throat and pelvis zones were considered insufficient. Thus, the results suggest that improved changes to ballistic protection for side of torso, neck, throat and pelvis zones may be warranted. It should be noted that while the questionnaire did not address facial protection, visors were a frequent discussion point.

Although 79% of participants indicated excessive thermal discomfort ("hot" and "very hot"), with the in-service PPE, caution is needed before making large changes to the in-service design because of extreme conditions in Afghanistan. The results do suggest that improvements in ventilation could improve the thermal comfort of vehicle crews.

Physical discomfort feedback with the in-service PPE identified chaffing issues with the current collar design. Consideration should be made to redesigning the neck opening and or changing collar liner materials.

The freedom of movement provided by the in-service PPE was generally acceptable. Issues with neck and trunk region were noted. Although the participants did report the range of motion to be acceptable in the shoulder area, many reported that they did not wear the shoulder pads. They reported that the current shoulder pad design inhibits movement into and out of hatches. The results of this investigation suggest that the shoulder pad design needs modification.

In-service PPE compatibility with clothing, weapons and equipment was generally acceptable. Although Air Sentries identified a number of compatibility issues, the sample size was too small to draw definitive conclusions.

5.4 Common Vehicle Issues

The current design of pintle-mounted machineguns is not fully compatible with the threats faced in Afghanistan. CCs, Gunners and Loaders weapons need to significantly expose their bodies to accurately engage close-in targets. The participants identified the need to reduce the height of the pintle-mounted machineguns to reduce exposure.

In addition to the height of pintle-mounted machineguns, participants indicated that many of these machineguns were not equipped with spade grips. Spade grips will allow the CC to properly engage targets and reduce body exposure.

5.5 Potential PPE Additions

The participants suggested a number of protective items that should be examined for use in mounted operations. These items (in no particular order) included the following:

- Visor,
- Upper limb protector,
- Throat guard,
- Side plates, and
- Groin protector.

The participants strongly indicated that any improvement in ballistic protection must not negatively influence task performance. Impacts on range of motion, physical comfort, thermal comfort and task performance must be evaluated prior to fielding additional armour. Crew tasks, ranges of motion, etc. identified in this BTA should serve as the basis for future PPE performance assessments.

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Annex A: Operational Scenarios:

List of Figures

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Operational Scenarios

A1 Quick Reaction Force – Close Country

The following is a quick reaction force scenario where a convoy of 4 LAV IIIs and a G-wagon is required to aid a group of dismounted infantry soldiers who have been attacked and ambushed within an urban Afghani town. The convoy of armoured vehicles get the call while they are having lunch outside of the town.

- A group of dismounted infantry soldiers are attacked and ambushed within an urban Afghani town.
- A distress call from the soldiers comes to an advanced contact position where a group of dismounted soldiers are having lunch.
- Once the call comes in, the soldiers have approximately two minutes to get their kit on.
- Once their kit is on, soldiers will access the vehicles in a normal fashion.
- Those who are unable to get their kit on within two minutes must access the vehicle quickly and finish putting on their kit inside the vehicle.
- A convoy of five armoured vehicles (4 LAV IIIs and a G-wagon) depart for the urban area (carrying a platoon of approximately 30 soldiers) to support already engaged soldiers. The convoy travels with two LAV IIIs at the front and back, with a G-wagon sandwiched in between them (See Figure A-).
- The urban area is approximately 35 miles away and there is only one main route to the urban area.
- **What are tasks during normal travel along a main supply route (MSR)?** *Scanning/ Reaching to Controls to maintain operation of vehicle/ reaching to weapons*

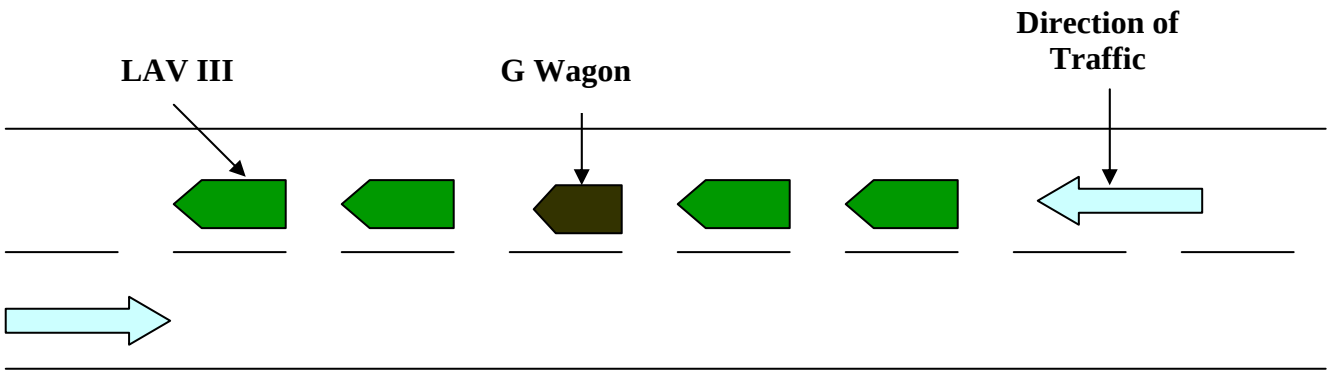

Figure A-1: Afghani 2-Lane Highway

- Along the way from the base to the urban area the convoy must travel through a long road of high sides.
- **What are the tasks performed while attempting a safe passage through a stretch of road with high sides?** *Viewing/ Reaching/ Control of gauges to maintain operation of vehicle*
- The convoy successfully travels through the high sides that are present en route to the urban area.
- Convoy approaches city limits, as roadside trash becomes more concentrated.
- **What are the tasks performed while viewing for IEDs in high concentrations of roadside trash?** *Viewing/ Weapons*
- While continuing to drive down the road the lead vehicle notices a pile of garbage on the side of the road with what looks like a wire coming out of it (See Figure A-).

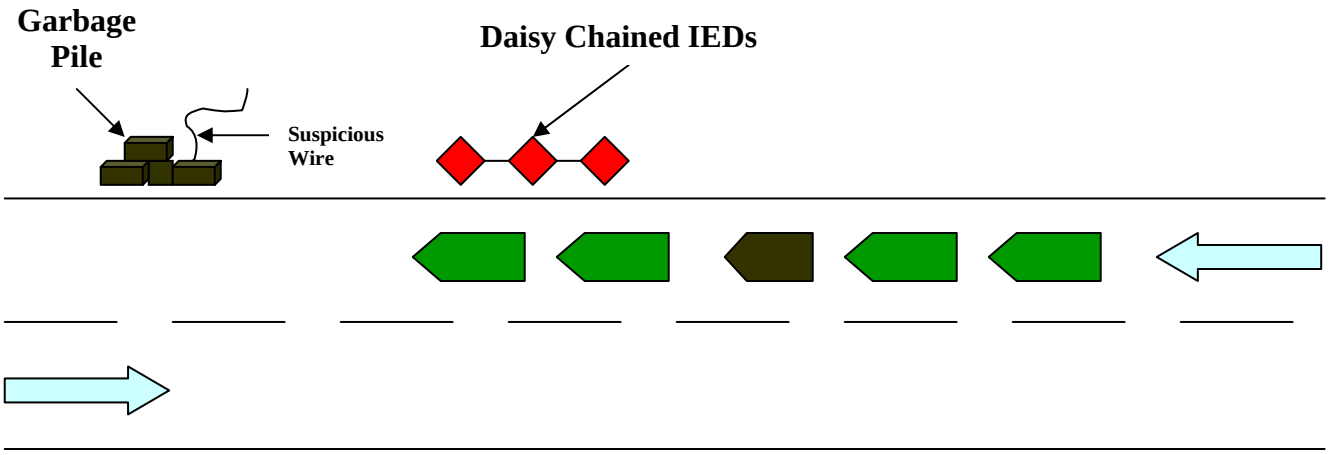

Figure A-2: Convoy Notices Suspicious Wire

- The convoy halts and calls in the wire.
- In the meantime, a set of daisy chained IEDs explode close to where the convoy is waiting taking out the lead vehicle (See Figure A-).

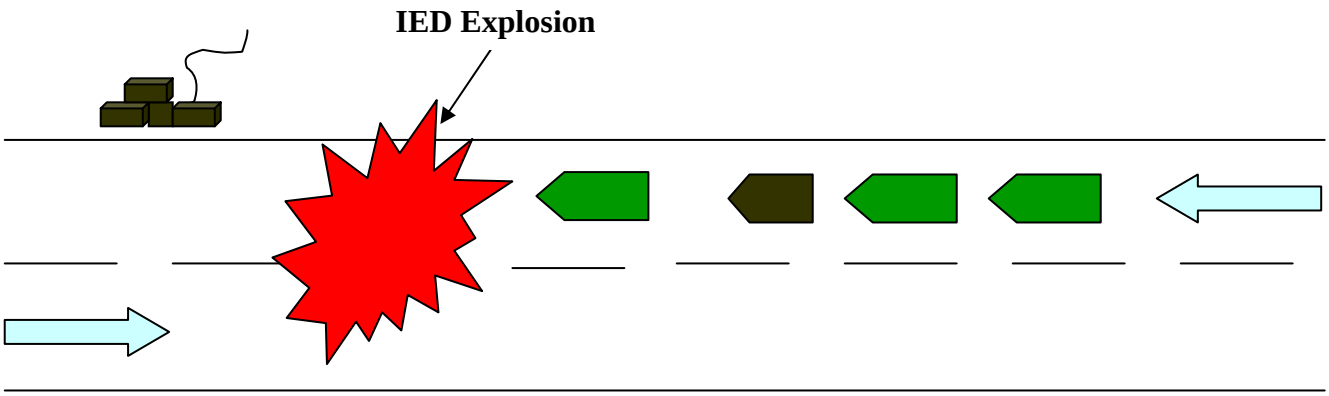

Figure A-3: IED Explosion Targeting First 2 Vehicles of the Convoy

- Everyone in the convoy gets down except for the air sentries.
- The vehicle directly behind the explosion drives past the explosion and secures the area past the explosion (while in motion the air sentries go down and close the family hatch).
- The 2nd vehicle behind the explosion drives up to the targeted vehicles and shields off the side that got hit (See Figure A-)
- The ramps of the vehicles drop and the crewmen dismount and the ramp closes behind them.
- A visual scan of 5 metres surrounding the wire and a physical search of 20 metres surrounding the wire is performed.
- **What does the convoy do?**
- **What are the tasks of the soldiers?**
- **Does this change whether you are the lead vehicle, middle vehicle(s), or trail vehicle?**

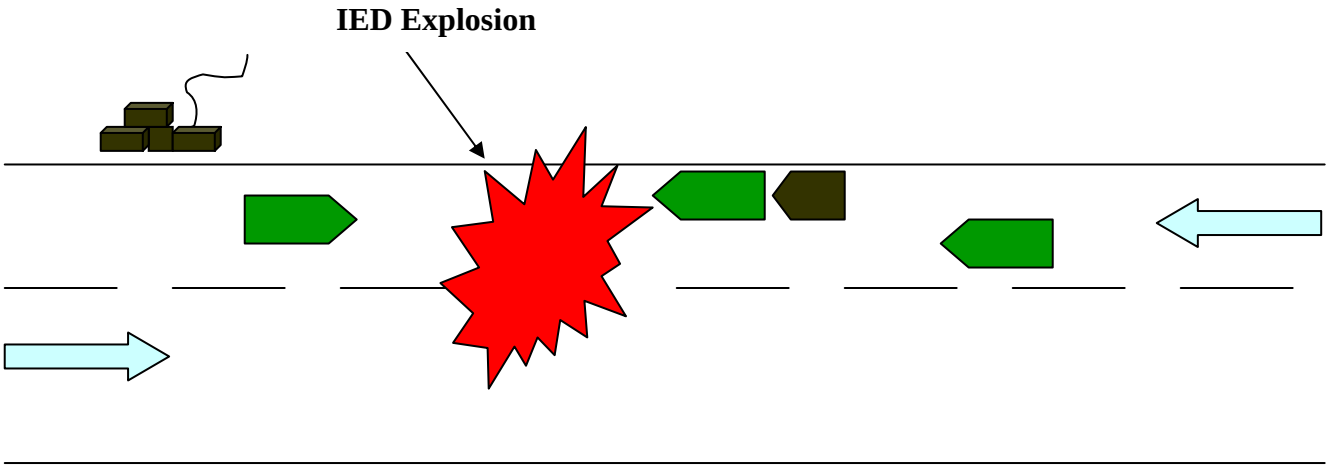

Figure A-4: Vehicles Move into Position Following IED Attack

- While dismounted the soldiers attempt to get the soldiers that were targeted by the IED out of their vehicle (internally or externally).
- **What tasks are performed immediately following the detonation of an IED?** *Control of Weapons/ Emergency Egress*
- **How do you prepare for subsequent explosions or fire fight?**
- Once the driver of the targeted vehicle has been extracted, CPR is needed to regain consciousness of the driver.
- **How do you perform CPR on an unconscious soldier?**

A2 Broken Down Vehicle – Inside City Scenario

The following is a scenario where a vehicle within the convoy breaks down in an urban area. Soldiers must secure the area surrounding the vehicle and transport the vehicle to a safe spot where it can be tended to.

- A convoy of five armoured vehicles are on a peace keeping patrol within a city.
- The second vehicle in the convoy suffers some sort of electronic malfunction and becomes disabled.
- **What are the tasks of the soldiers as a vehicle within the convoy breaks down? Soldiers within the broken down vehicle? Soldiers of other vehicles?** *Viewing/ Weapons/ Vehicle Control*
- All soldiers provide an 'all around defence' tactic to protect the vehicles and keep civilians at a distance.
- The air sentries cover the rear while the driver covers forward.
- A suspicious person begins walking towards the convoy from the side and ignores the soldiers recommendations to stay back.
- The person comes with 4 ft. of a vehicle.
- **Show how the air sentries engage this target?**
- The person is engaged and is killed.
- Acknowledging that the broken down vehicle is not in a safe spot the soldiers need to attach tow cables and bring the vehicle to a safe spot.
- **What are the tasks performed during the installation of the tow cables?**
- The broke down vehicle is towed to a safe spot where maintenance can be performed.
- On the way to the safe spot the broke down vehicle suffers a blown tire.
- The blown tire needs to be repaired as well.
- **Assume little PPE is worn during tire change.**

- **What tasks are performed by the soldiers during the repairing of the tire? And general maintenance of the vehicle?**

A3 Engage Targets

The following scenario involves an isolated vehicle that comes under attack.

- A single armoured vehicle is on a patrol in an urban Afghani town.
- A single car approaches the armoured vehicle.

This scenario can be revised to include a car coming from either front/ back/ or side.

- The armoured vehicle fires a warning shot to halt the vehicle from coming any closer.
- The occupants of the vehicle jump out and run into a building.
- All of a sudden the armoured vehicle comes under gunfire attack.
- **What are the roles of the soldiers when they come under attack and engage targets?**
- The commander uses the pintle mount to engage the targets while the gunner passes him the ammo.
- The C6 being fired by the CComd experiences a stoppage and the CComd must switch to his personal weapon to continue fight.
- The soldiers must use a lot of ammo to neutralize the combatants.
- The air sentries need to change their mags frequently and fire M72s and 40 mm as well.
- *If G-wagon – they must fire their C7s out of an open door.*
- The soldiers experience a problem with the feeder to the pintle mount.
- The chute and feeder need to be removed and replaced.
- **What are the tasks of the soldiers when they are firing their weapons?**
- **What are the tasks of the other soldiers when they have to remove and replace the chute and feeder?**

A4 Vehicle-Borne IED (VBIED)

The following scenario involves a convoy that has been deployed to provide supplies to a group of dismounted soldiers. The convoy travels down a main road in Kandahar and encounters many approaching vehicles.

- A convoy of five vehicles is deployed in order to provide supplies to a group of dismounted soldiers.
- The convoy must travel along a typical two-lane Afghani highway that serves as a main supply route (MSR) to the area.
- **What are tasks during normal travel along a main supply route?** *Viewing/ Reaching to Controls to maintain operation of vehicle/ reaching to weapons*
- The convoy travels in a staggered formation with a 5 m separation (See Figure A-).
- As the convoy travels down the highway several oncoming cars pull over and allow passage of the convoy.
- **What are the tasks of the soldiers when they encounter approaching vehicles that pull over and may not pose a threat?** *Viewing/ Weapons/ Vehicle Control*
- The convoy notices a vehicle approaching that is not pulling over and is approaching the convoy at a high speed.

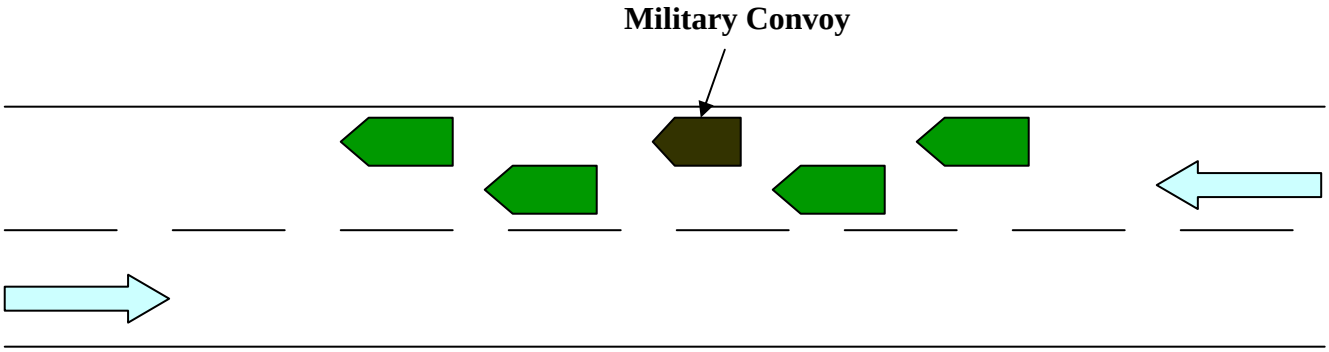

Figure A-5: Military Convoy Driving in a Staggered Formation

- **Do the soldiers take part in any defensive measures to prepare for possible combat?**
- **What are the precautions taken?**
- As the oncoming vehicle comes closer, the first vehicle of the convoy begins to wave off the car with the pistol.
- The oncoming vehicle continues to bear into the lead vehicle of the convoy.
- The gunner (turret if vehicle is from the front, air sentry if vehicle is from the back) fires a few shots into the ground in front of the approaching vehicle.

- **What are the tasks of the soldiers after the warning shots are fired and the threat level increases?**
- **What are the tasks performed by the soldiers in the 1st, 2nd, 3rd, 4th, and 5th vehicles in the convoy?** *Viewing/ Weapons/ Vehicle Control/ Emergency Egress*
- The oncoming vehicle approaches the exclusion zone and the convoy begins to open fire onto the incoming vehicle (See Figure A-).
- **What are the tasks performed by the soldiers in the 1st, 2nd, 3rd, 4th, and 5th vehicles in the convoy?** *Viewing/ Weapons/ Vehicle Control/ Emergency Egress*
- The vehicle does not halt and crashes into the lead car of the convoy and explodes killing the driver, CComd, and a single air sentry.
- Fragments from the blast impact the CComd of the following vehicle in the left shoulder causing him to drop in the hatch.
- An air sentry from the 2nd vehicle drops in the hatch to provide first aid to the fallen CComd.

OR

- No air sentry is available to help so the CComd must provide aid to himself.
- Other soldiers egress from their vehicles and attempt a rapid extraction of the remaining soldier still alive in the lead car.
- The soldier is successfully extracted and only suffers from minor injuries.
- **How does this scenario change if the VBIED came from behind?**

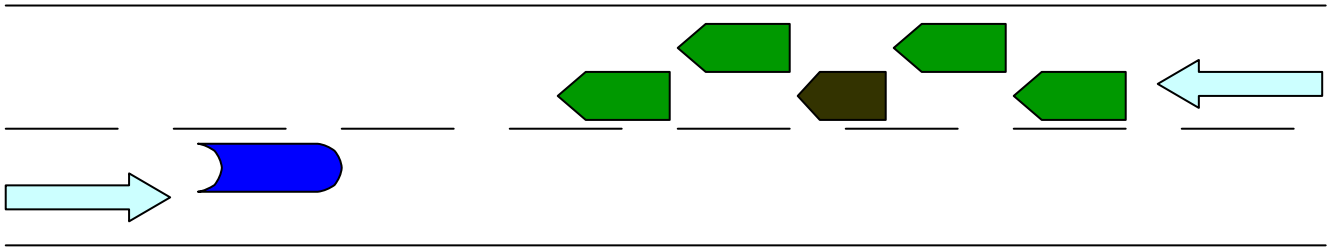

Figure A-6: Vehicle Approaches Military Convoy

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Annex B:
PPE Questionnaires

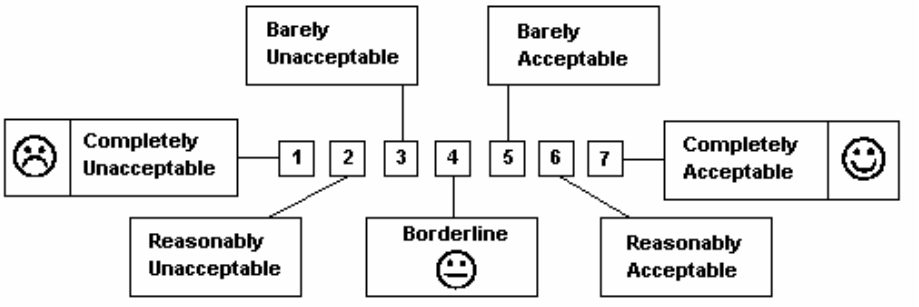
COUNTER IED QUESTIONNAIRE

NAME: _____ PARTICIPANT NUMBER: _____

UNIT: _____ VEHICLE: _____

POSITION: _Air Sentry_____ PPE:_____

REMEMBER THE SCALE:



BALLISTIC COVERAGE

Rate the ballistic coverage of the PPE in the following areas:	Acceptability of Coverage ☹ 😐 ☺ 1	2	3	4	5	6	7
Upper Chest	O	O	O	O	O	O	O
Upper Back	O	O	O	O	O	O	O
Abdomen	O	O	O	O	O	O	O
Lower Back	O	O	O	O	O	O	O
Side of Torso	O	O	O	O	O	O	O
Throat	O	O	O	O	O	O	O
Neck (Sides & Back)	O	O	O	O	O	O	O
Groin	O	O	O	O	O	O	O
Pelvis	O	O	O	O	O	O	O
Shoulders	O	O	O	O	O	O	O
Upper Arms	O	O	O	O	O	O	O
Legs	O	O	O	O	O	O	O
OVERALL COVERAGE RATING	O	O	O	O	O	O	O

Comments:

COMPATIBILITY

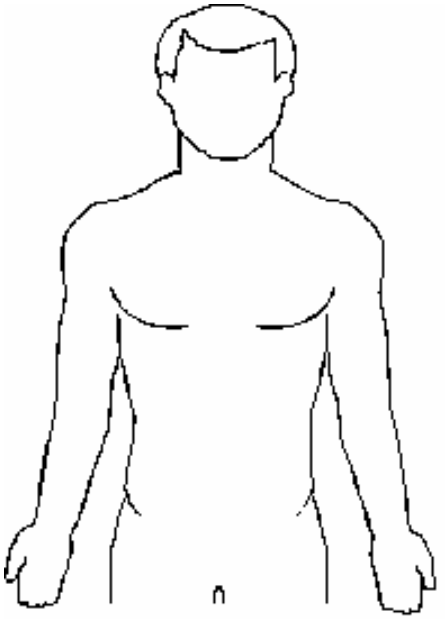
CLOTHING							
Rate the compatibility of the PPE in the following areas:	☹ 1	2	3	😐 4	5	6	☺ 7
Crew Helmet	O	O	O	O	O	O	O
Fragmentation Vest (if appropriate)	O	O	O	O	O	O	O
IECS Middle Layer Jacket	O	O	O	O	O	O	O
Small pack	O	O	O	O	O	O	O
Tactical Vest	O	O	O	O	O	O	O
CG634 Helmet	O	O	O	O	O	O	O
OVERALL CLOTHING COMPATIBILITY	**O**	**O**	**O**	**O**	**O**	**O**	**O**
WEAPONS AND EQUIPMENT							
Rate the compatibility of the PPE with the following weapons & equipment:	☹ 1	2	3	😐 4	5	6	☺ 7
.50 cal machine gun	O	O	O	O	O	O	O
C7-A1 Rifle	O	O	O	O	O	O	O
Flashbangs	O	O	O	O	O	O	O
Smoke Grenades	O	O	O	O	O	O	O
Frag Grenades	O	O	O	O	O	O	O
M72s	O	O	O	O	O	O	O
40mm	O	O	O	O	O	O	O
Slings	O	O	O	O	O	O	O
Night Vision Goggles	O	O	O	O	O	O	O
Binoculars	O	O	O	O	O	O	O
Radios	O	O	O	O	O	O	O
- 521	O	O	O	O	O	O	O
- 522	O	O	O	O	O	O	O
- 117	O	O	O	O	O	O	O
- Overall Radio Compatibility	**O**	**O**	**O**	**O**	**O**	**O**	**O**
C6	O	O	O	O	O	O	O
9mm Pistol	O	O	O	O	O	O	O
OVERALL WEAPONS AND EQUIPMENT COMPATIBILITY	**O**	**O**	**O**	**O**	**O**	**O**	**O**
MOUNTED CREWMAN TASKS- Air Sentry							
Rate the compatibility of the PPE with the following Mounted Crewmen Tasks:	☹ 1	2	3	😐 4	5	6	☺ 7
Donning PPE	O	O	O	O	O	O	O
Doffing PPE	O	O	O	O	O	O	O
Scanning/ covering arcs	O	O	O	O	O	O	O
Changing mags, ammo boxes for C6/ ammo for C9	O	O	O	O	O	O	O
Firing M72s and 40 mms/ throwing grenades	O	O	O	O	O	O	O
Being extracted internally/ externally	O	O	O	O	O	O	O

Helping to extract soldiers from vehicles	O	O	O	O	O	O	O
Roles after vehicle in convoy is hit from the side by a vehicle	O	O	O	O	O	O	O
Providing first aid, within vehicle, to soldiers injured by IED	O	O	O	O	O	O	O
Providing self aid, within vehicle, after impact with IED	O	O	O	O	O	O	O
Waving off approaching persons/ vehicles	O	O	O	O	O	O	O
Scanning high sides	O	O	O	O	O	O	O
Scanning for IEDs in highly concentrated areas (ex. Trash build up areas)	O	O	O	O	O	O	O
Normal access/ egress	O	O	O	O	O	O	O
Emergency access/ egress	O	O	O	O	O	O	O
Closing family hatches	O	O	O	O	O	O	O
Visual scan of 5m	O	O	O	O	O	O	O
Physical scan of 25m	O	O	O	O	O	O	O
OVERALL MOUNTED CREWMEN TASK COMPATIBILITY	**O**	**O**	**O**	**O**	**O**	**O**	**O**
DISMOUNTED CREWMEN TASKS							
Rate the compatibility of the PPE with the following Dismounted Crewmen Tasks:	☹ **1**	**2**	**3**	😐 **4**	**5**	**6**	☺ **7**
Long Distance Walking	O	O	O	O	O	O	O
Securing Areas	O	O	O	O	O	O	O
Firing in Kneeling Position	O	O	O	O	O	O	O
Toss Smoke Grenades, Flashbangs	O	O	O	O	O	O	O
Attaching Tow Cables for Quick Tow (if applicable)	O	O	O	O	O	O	O
Changing Vehicle Tires	O	O	O	O	O	O	O
Vehicle Maintenance Tasks	O	O	O	O	O	O	O
Securing Loads	O	O	O	O	O	O	O
Performing a Rolling Replenishment	O	O	O	O	O	O	O
Carrying Full Kit	O	O	O	O	O	O	O
Room Search	O	O	O	O	O	O	O
Crawling	O	O	O	O	O	O	O
Manoeuvring through small 'Yoda' doors	O	O	O	O	O	O	O
Combat Shooting	O	O	O	O	O	O	O
Providing First Aid to other Soldiers	O	O	O	O	O	O	O
Receiving First Aid form other Soldiers	O	O	O	O	O	O	O
Carrying Injured Soldiers Over Large Distances	O	O	O	O	O	O	O
OVERALL DISMOUNTED CREWMEN TASK COMPATIBILITY	**O**	**O**	**O**	**O**	**O**	**O**	**O**
Comments:							

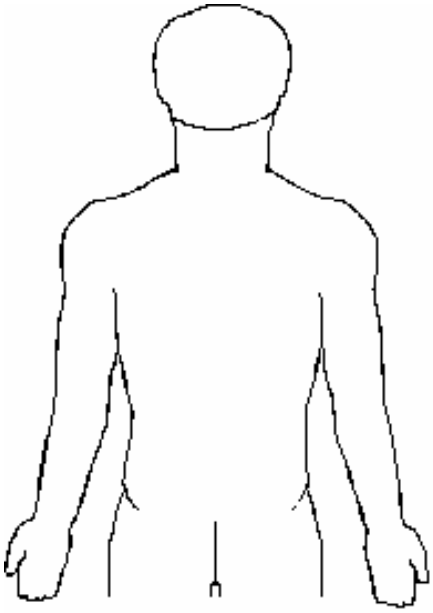
PHYSICAL DISCOMFORT

Using the different views of the torso below, draw in the areas where you might feel physical discomfort. Indicate how much discomfort with a number from the scale to the right.	Neutral 1	Slight Discomfort 2	Noticeable Discomfort 3	Pain 4	Extreme Pain 5

FRONT



BACK



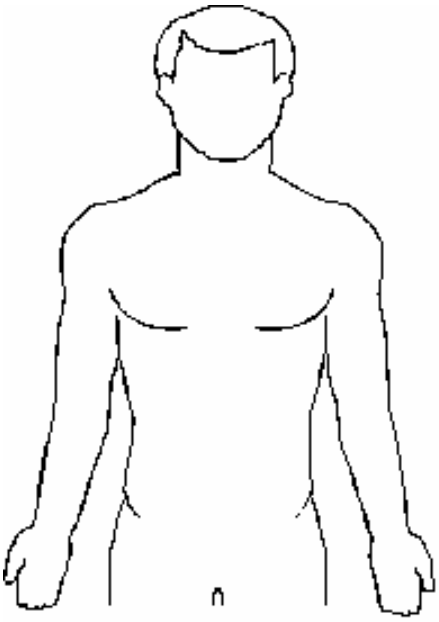
Rate the following aspects of physical comfort:	☹ 1	2	3	😐 4	5	6	☺ 7
Breathing Constriction	O	O	O	O	O	O	O
Pressure Points while Stationary	O	O	O	O	O	O	O
Pressure Points while Moving	O	O	O	O	O	O	O
Chaffing	O	O	O	O	O	O	O
OVERALL PHYSICAL COMFORT	**O**	**O**	**O**	**O**	**O**	**O**	**O**

COMMENTS:

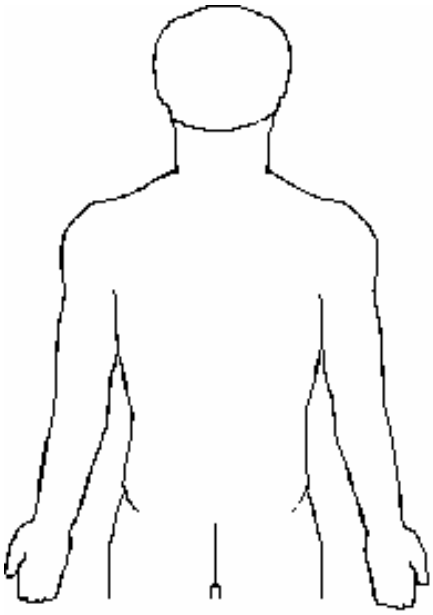
THERMAL DISCOMFORT

Using the different views of the torso below, draw in the areas where you might feel thermal discomfort. Indicate how much discomfort with a number from the scale to the right.	**Neutral** 1	**Slightly Warm** 2	**Noticeably Warm** 3	**Hot** 4	**Very Hot** 5

FRONT



BACK



Rate the following aspects of thermal comfort:	☹ 1	2	3	😐 4	5	6	☺ 7
Hot Spots	O	O	O	O	O	O	O
Ventilation	O	O	O	O	O	O	O
OVERALL THERMAL COMFORT	**O**	**O**	**O**	**O**	**O**	**O**	**O**

COMMENTS:

Range of Motion

Rate the effect the PPE has on the following motions:	☹ 1	2	3	😐 4	5	6	☺ 7
Shoulder							
- Flexion	O	O	O	O	O	O	O
- Extension	O	O	O	O	O	O	O
- Abduction	O	O	O	O	O	O	O
- Adduction	O	O	O	O	O	O	O
OVERALL SHOULDER MOTION	**O**	**O**	**O**	**O**	**O**	**O**	**O**
Elbow							
- Flexion	O	O	O	O	O	O	O
- Extension	O	O	O	O	O	O	O
OVERALL ELBOW MOTION	**O**	**O**	**O**	**O**	**O**	**O**	**O**
Neck							
- Flexion	O	O	O	O	O	O	O
- Extension	O	O	O	O	O	O	O
- Rotation	O	O	O	O	O	O	O
OVERALL NECK MOTION	**O**	**O**	**O**	**O**	**O**	**O**	**O**
Trunk							
- Flexion	O	O	O	O	O	O	O
- Extension	O	O	O	O	O	O	O
- Lateral Bending	O	O	O	O	O	O	O
- Rotation	O	O	O	O	O	O	O
OVERALL TRUNK MOTION	**O**	**O**	**O**	**O**	**O**	**O**	**O**
Knee							
- Flexion	O	O	O	O	O	O	O
- Extension	O	O	O	O	O	O	O
OVERALL KNEE MOTION	**O**	**O**	**O**	**O**	**O**	**O**	**O**
Hip							
- Flexion	O	O	O	O	O	O	O
- Extension	O	O	O	O	O	O	O
- Abduction	O	O	O	O	O	O	O
- Adduction	O	O	O	O	O	O	O
OVERALL HIP MOTION	**O**	**O**	**O**	**O**	**O**	**O**	**O**
Wrist							
- Flexion	O	O	O	O	O	O	O
- Extension	O	O	O	O	O	O	O
OVERALL WRIST MOTION	**O**	**O**	**O**	**O**	**O**	**O**	**O**
Comments:							

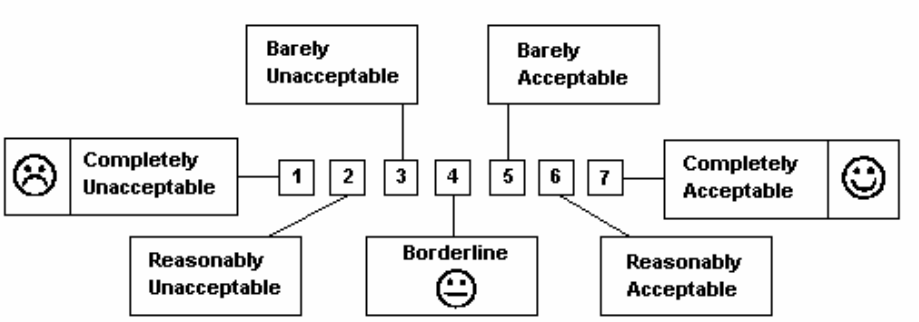
COUNTER IED QUESTIONNAIRE

NAME: _____ PARTICIPANT NUMBER: _____

UNIT: _____ VEHICLE: _____

POSITION: __Driver_____ PPE:_____

REMEMBER THE SCALE:



BALLISTIC COVERAGE

Rate the ballistic coverage of the PPE in the following areas:	Acceptability of Coverage ☹ 1	2	3	😐 4	5	6	☺ 7
Upper Chest	O	O	O	O	O	O	O
Upper Back	O	O	O	O	O	O	O
Abdomen	O	O	O	O	O	O	O
Lower Back	O	O	O	O	O	O	O
Side of Torso	O	O	O	O	O	O	O
Throat	O	O	O	O	O	O	O
Neck (Sides & Back)	O	O	O	O	O	O	O
Groin	O	O	O	O	O	O	O
Pelvis	O	O	O	O	O	O	O
Shoulders	O	O	O	O	O	O	O
Upper Arms	O	O	O	O	O	O	O
Legs	O	O	O	O	O	O	O
OVERALL COVERAGE RATING	O	O	O	O	O	O	O

Comments:

COMPATIBILITY

CLOTHING							
Rate the compatibility of the PPE in the following areas:	☹			😐			☺
	1	**2**	**3**	**4**	**5**	**6**	**7**
Crew Helmet	O	O	O	O	O	O	O
Fragmentation Vest (if appropriate)	O	O	O	O	O	O	O
IECS Middle Layer Jacket	O	O	O	O	O	O	O
Small pack	O	O	O	O	O	O	O
Tactical Vest	O	O	O	O	O	O	O
CG 634 Helmet	O	O	O	O	O	O	O
OVERALL CLOTHING COMPATIBILITY	**O**	**O**	**O**	**O**	**O**	**O**	**O**
WEAPONS AND EQUIPMENT							
Rate the compatibility of the PPE with the following weapons & equipment:	☹			😐			☺
	1	**2**	**3**	**4**	**5**	**6**	**7**
.50 cal machine gun	O	O	O	O	O	O	O
C7-A1 Rifle	O	O	O	O	O	O	O
Flashbangs	O	O	O	O	O	O	O
Smoke Grenades	O	O	O	O	O	O	O
Frag Grenades	O	O	O	O	O	O	O
M72s	O	O	O	O	O	O	O
40mm	O	O	O	O	O	O	O
Slings	O	O	O	O	O	O	O
Night Vision Goggles	O	O	O	O	O	O	O
Binoculars	O	O	O	O	O	O	O
Radios	O	O	O	O	O	O	O
- 521	O	O	O	O	O	O	O
- 522	O	O	O	O	O	O	O
- 117	O	O	O	O	O	O	O
- Overall Radio Compatibility	**O**	**O**	**O**	**O**	**O**	**O**	**O**
C6	O	O	O	O	O	O	O
9mm Pistol	O	O	O	O	O	O	O
OVERALL WEAPONS AND EQUIPMENT COMPATIBILITY	**O**	**O**	**O**	**O**	**O**	**O**	**O**
MOUNTED CREWMAN TASKS- Driver							
Rate the compatibility of the PPE with the following Mounted Crewmen Tasks:	☹			😐			☺
	1	**2**	**3**	**4**	**5**	**6**	**7**
Donning PPE	O	O	O	O	O	O	O
Doffing PPE	O	O	O	O	O	O	O
Control of vehicle (steering, braking, reaching)	O	O	O	O	O	O	O
Scanning/ covering arcs	O	O	O	O	O	O	O
Being extracted internally/ externally	O	O	O	O	O	O	O
Helping to extract soldiers from vehicles	O	O	O	O	O	O	O
Providing first aid, within vehicle, to soldiers injured by IED	O	O	O	O	O	O	O

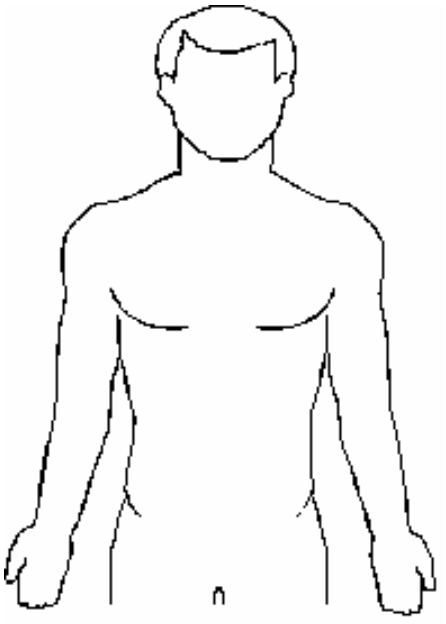
Providing self aid, within vehicle, after impact with IED	O	O	O	O	O	O	O
Scanning for IEDs in highly concentrated areas (ex. Trash build up areas)	O	O	O	O	O	O	O
Normal access/ egress	O	O	O	O	O	O	O
Emergency access/ egress	O	O	O	O	O	O	O
Visual scan of 5m	O	O	O	O	O	O	O
Physical scan of 25m	O	O	O	O	O	O	O
OVERALL MOUNTED CREWMEN TASK COMPATIBILITY	**O**	**O**	**O**	**O**	**O**	**O**	**O**
DISMOUNTED CREWMEN TASKS							
Rate the compatibility of the PPE with the following Dismounted Crewmen Tasks:	☹ **1**	**2**	**3**	😐 **4**	**5**	**6**	☺ **7**
Long Distance Walking	O	O	O	O	O	O	O
Securing Areas	O	O	O	O	O	O	O
Firing in Kneeling Position	O	O	O	O	O	O	O
Toss Smoke Grenades, Flashbangs	O	O	O	O	O	O	O
Attaching Tow Cables for Quick Tow (if applicable)	O	O	O	O	O	O	O
Changing Vehicle Tires	O	O	O	O	O	O	O
Vehicle Maintenance Tasks	O	O	O	O	O	O	O
Securing Load	O	O	O	O	O	O	O
Performing a Rolling Replenishment	O	O	O	O	O	O	O
Carrying Full Kit	O	O	O	O	O	O	O
Room Search	O	O	O	O	O	O	O
Crawling	O	O	O	O	O	O	O
Manoeuvring through small 'Yoda' doors	O	O	O	O	O	O	O
Combat Shooting	O	O	O	O	O	O	O
Providing First Aid to other Soldiers	O	O	O	O	O	O	O
Receiving First Aid form other Soldiers	O	O	O	O	O	O	O
Carrying Injured Soldiers Over Large Distances	O	O	O	O	O	O	O
OVERALL DISMOUNTED CREWMEN TASK COMPATIBILITY	**O**	**O**	**O**	**O**	**O**	**O**	**O**

Comments:

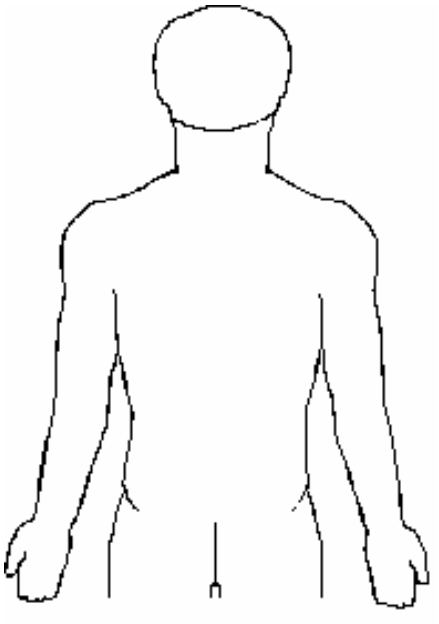
PHYSICAL DISCOMFORT

Using the different views of the torso below, draw in the areas where you might feel physical discomfort. Indicate how much discomfort with a number from the scale to the right.	Neutral 1	Slight Discomfort 2	Noticeable Discomfort 3	Pain 4	Extreme Pain 5

FRONT



BACK



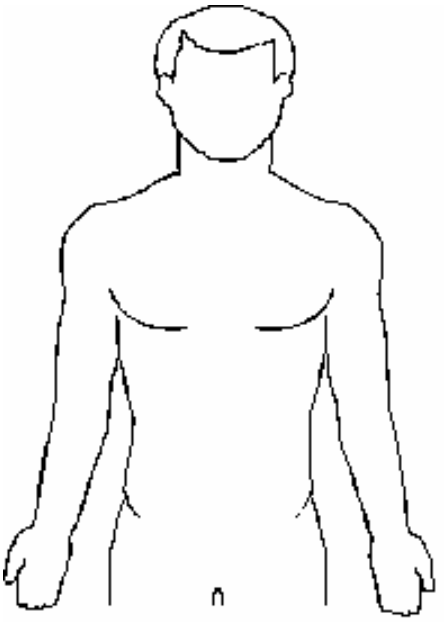
Rate the following aspects of physical comfort:	☹ 1	2	3	😐 4	5	6	☺ 7
Breathing Constriction	O	O	O	O	O	O	O
Pressure Points while Stationary	O	O	O	O	O	O	O
Pressure Points while Moving	O	O	O	O	O	O	O
Chaffing	O	O	O	O	O	O	O
OVERALL PHYSICAL COMFORT	**O**	**O**	**O**	**O**	**O**	**O**	**O**

COMMENTS:

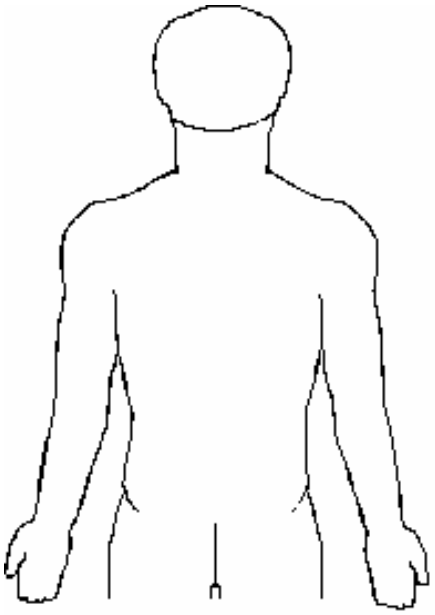
THERMAL DISCOMFORT

Using the different views of the torso below, draw in the areas where you might feel thermal discomfort. Indicate how much discomfort with a number from the scale to the right.	Neutral 1	Slightly Warm 2	Noticeably Warm 3	Hot 4	Very Hot 5

FRONT



BACK



Rate the following aspects of thermal comfort:	☹ 1	2	3	😐 4	5	6	☺ 7
Hot Spots	O	O	O	O	O	O	O
Ventilation	O	O	O	O	O	O	O
OVERALL THERMAL COMFORT	**O**	**O**	**O**	**O**	**O**	**O**	**O**

COMMENTS:

Range of Motion

Rate the effect the PPE has on the following motions:	☹ 1	2	3	😐 4	5	6	☺ 7
Shoulder							
- Flexion	O	O	O	O	O	O	O
- Extension	O	O	O	O	O	O	O
- Abduction	O	O	O	O	O	O	O
- Adduction	O	O	O	O	O	O	O
OVERALL SHOULDER MOTION	**O**	**O**	**O**	**O**	**O**	**O**	**O**
Elbow							
- Flexion	O	O	O	O	O	O	O
- Extension	O	O	O	O	O	O	O
OVERALL ELBOW MOTION	**O**	**O**	**O**	**O**	**O**	**O**	**O**
Neck							
- Flexion	O	O	O	O	O	O	O
- Extension	O	O	O	O	O	O	O
- Rotation	O	O	O	O	O	O	O
OVERALL NECK MOTION	**O**	**O**	**O**	**O**	**O**	**O**	**O**
Trunk							
- Flexion	O	O	O	O	O	O	O
- Extension	O	O	O	O	O	O	O
- Lateral Bending	O	O	O	O	O	O	O
- Rotation	O	O	O	O	O	O	O
OVERALL TRUNK MOTION	**O**	**O**	**O**	**O**	**O**	**O**	**O**
Knee							
- Flexion	O	O	O	O	O	O	O
- Extension	O	O	O	O	O	O	O
OVERALL KNEE MOTION	**O**	**O**	**O**	**O**	**O**	**O**	**O**
Hip							
- Flexion	O	O	O	O	O	O	O
- Extension	O	O	O	O	O	O	O
- Abduction	O	O	O	O	O	O	O
- Adduction	O	O	O	O	O	O	O
OVERALL HIP MOTION	**O**	**O**	**O**	**O**	**O**	**O**	**O**
Wrist							
- Flexion	O	O	O	O	O	O	O
- Extension	O	O	O	O	O	O	O
OVERALL WRIST MOTION	**O**	**O**	**O**	**O**	**O**	**O**	**O**
Comments:							

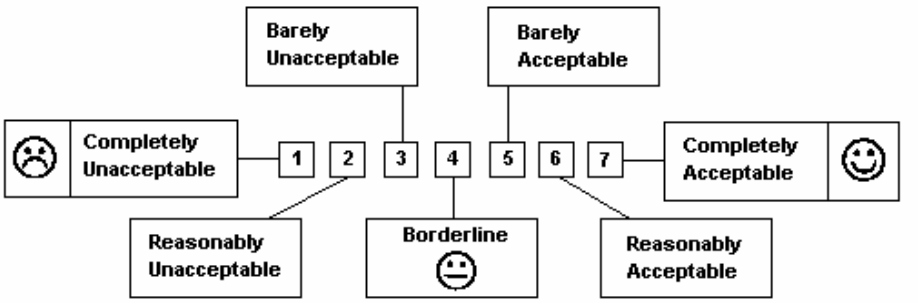
COUNTER IED QUESTIONNAIRE

NAME: _____ PARTICIPANT NUMBER: _____

UNIT: _____ VEHICLE: _____

POSITION: _CComd_____ PPE:_____

REMEMBER THE SCALE:



BALLISTIC COVERAGE

Rate the ballistic coverage of the PPE in the following areas:	Acceptability of Coverage ☹ 1	2	3	😐 4	5	6	☺ 7
Upper Chest	O	O	O	O	O	O	O
Upper Back	O	O	O	O	O	O	O
Abdomen	O	O	O	O	O	O	O
Lower Back	O	O	O	O	O	O	O
Side of Torso	O	O	O	O	O	O	O
Throat	O	O	O	O	O	O	O
Neck (Sides & Back)	O	O	O	O	O	O	O
Groin	O	O	O	O	O	O	O
Pelvis	O	O	O	O	O	O	O
Shoulders	O	O	O	O	O	O	O
Upper Arms	O	O	O	O	O	O	O
Legs	O	O	O	O	O	O	O
OVERALL COVERAGE RATING	O	O	O	O	O	O	O

Comments:

COMPATIBILITY

CLOTHING							
Rate the compatibility of the PPE with the following:	☹			😐			☺
	1	**2**	**3**	**4**	**5**	**6**	**7**
Crew Helmet	O	O	O	O	O	O	O
Fragmentation Vest (if appropriate)	O	O	O	O	O	O	O
IECS Middle Layer Jacket	O	O	O	O	O	O	O
Small pack	O	O	O	O	O	O	O
Tactical Vest	O	O	O	O	O	O	O
CG 634 Helmet	O	O	O	O	O	O	O
OVERALL CLOTHING COMPATIBILITY	**O**	**O**	**O**	**O**	**O**	**O**	**O**
WEAPONS AND EQUIPMENT							
Rate the compatibility of the PPE with the following weapons & equipment:	☹			😐			☺
	1	**2**	**3**	**4**	**5**	**6**	**7**
.50 cal machine gun	O	O	O	O	O	O	O
C7-A1 Rifle	O	O	O	O	O	O	O
Flashbangs	O	O	O	O	O	O	O
Smoke Grenades	O	O	O	O	O	O	O
Frag Grenades	O	O	O	O	O	O	O
M72s	O	O	O	O	O	O	O
40mm	O	O	O	O	O	O	O
Slings	O	O	O	O	O	O	O
Night Vision Goggles	O	O	O	O	O	O	O
Binoculars	O	O	O	O	O	O	O
Radios	O	O	O	O	O	O	O
- 521	O	O	O	O	O	O	O
- 522	O	O	O	O	O	O	O
- 117	O	O	O	O	O	O	O
- Overall Radio Compatibility	**O**	**O**	**O**	**O**	**O**	**O**	**O**
C6	O	O	O	O	O	O	O
9mm Pistol	O	O	O	O	O	O	O
OVERALL WEAPONS AND EQUIPMENT COMPATIBILITY	**O**	**O**	**O**	**O**	**O**	**O**	**O**
MOUNTED CREWMAN TASKS- CComd							
Rate the compatibility of the current PPE with the following Mounted Crewmen Tasks:	☹			😐			☺
	1	**2**	**3**	**4**	**5**	**6**	**7**
Donning PPE	O	O	O	O	O	O	O
Doffing PPE	O	O	O	O	O	O	O
Scanning/ covering arcs	O	O	O	O	O	O	O
Waving off approaching persons/ vehicles	O	O	O	O	O	O	O
Scanning high sides	O	O	O	O	O	O	O
Scanning for IEDs in highly concentrated areas (ex. Trash build up areas)	O	O	O	O	O	O	O
Normal access/ egress	O	O	O	O	O	O	O

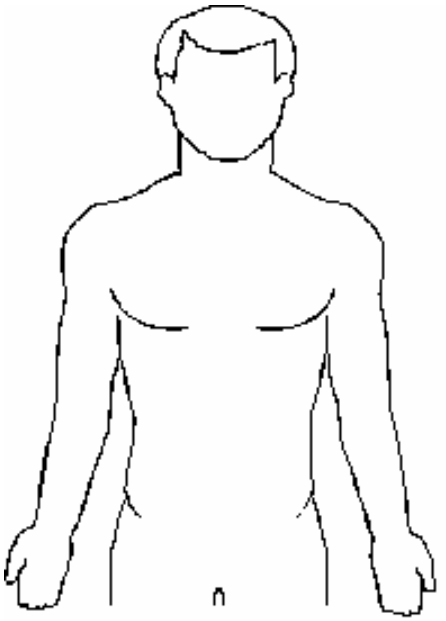
Emergency access/ egress	O	O	O	O	O	O	O
Acquiring Targets	O	O	O	O	O	O	O
Engagement of targets using pintle mount: at extremes (¼ - ½ right/ left)	O	O	O	O	O	O	O
Accessing personal weapons if M6 fails.	O	O	O	O	O	O	O
Being extracted internally/ externally	O	O	O	O	O	O	O
Reloading weapons/ handling stoppages	O	O	O	O	O	O	O
Reloading Mags/ other ammo	O	O	O	O	O	O	O
Exchanging Ammo Between Soldiers	O	O	O	O	O	O	O
Exgtracting Mounted Soldiers Internally/ Externally	O	O	O	O	O	O	O
OVERALL MOUNTED CREWMEN TASK COMPATIBILITY	**O**	**O**	**O**	**O**	**O**	**O**	**O**
DISMOUNTED CREWMEN TASKS							
Rate the compatibility of the PPE with the following Dismounted Crewmen Tasks:	☹			😐			☺
	1	**2**	**3**	**4**	**5**	**6**	**7**
Long Distance Walking	O	O	O	O	O	O	O
Securing Areas	O	O	O	O	O	O	O
Firing in Kneeling Position	O	O	O	O	O	O	O
Toss Smoke Grenades, Flashbangs	O	O	O	O	O	O	O
Attaching Tow Cables for Quick Tow (if applicable)	O	O	O	O	O	O	O
Changing Vehicle Tires	O	O	O	O	O	O	O
Vehicle Maintenance Tasks	O	O	O	O	O	O	O
Securing Loads	O	O	O	O	O	O	O
Performing a Rolling Replenishment	O	O	O	O	O	O	O
Carrying Assault Order	O	O	O	O	O	O	O
Room Search	O	O	O	O	O	O	O
Crawling	O	O	O	O	O	O	O
Manoeuvring through small 'Yoda' doors	O	O	O	O	O	O	O
Combat Shooting	O	O	O	O	O	O	O
Providing First Aid to other Soldiers	O	O	O	O	O	O	O
Receiving First Aid form other Soldiers	O	O	O	O	O	O	O
Carrying Injured Soldiers Over Large Distances	O	O	O	O	O	O	O
OVERALL DISMOUNTED CREWMEN TASK COMPATIBILITY	**O**	**O**	**O**	**O**	**O**	**O**	**O**

Comments:

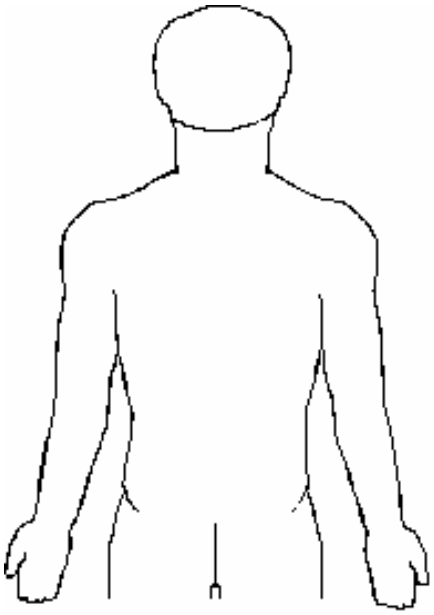
PHYSICAL DISCOMFORT

Using the different views of the torso below, draw in the areas where you might feel physical discomfort. Indicate how much discomfort with a number from the scale to the right.	Neutral 1	Slight Discomfort 2	Noticeable Discomfort 3	Pain 4	Extreme Pain 5

FRONT



BACK



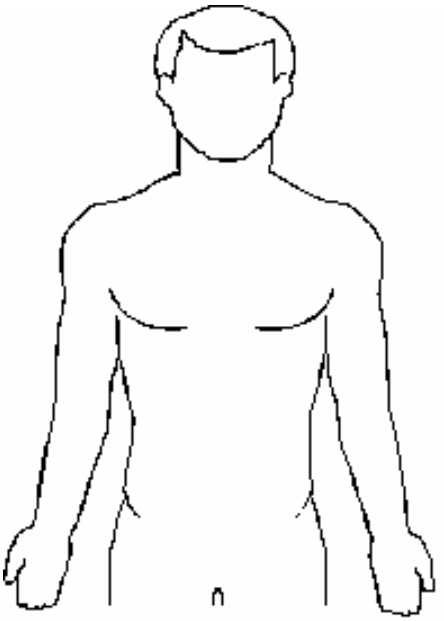
Rate the following aspects of physical comfort:	☹ 1	2	3	😐 4	5	6	☺ 7
Breathing Constriction	O	O	O	O	O	O	O
Pressure Points while Stationary	O	O	O	O	O	O	O
Pressure Points while Moving	O	O	O	O	O	O	O
Chaffing	O	O	O	O	O	O	O
OVERALL PHYSICAL COMFORT	**O**	**O**	**O**	**O**	**O**	**O**	**O**

COMMENTS:

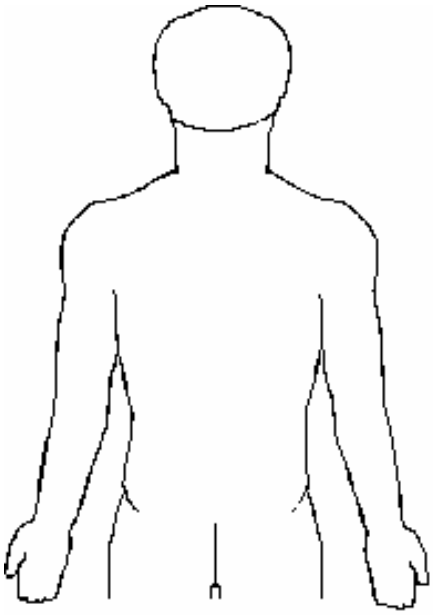
THERMAL DISCOMFORT

Using the different views of the torso below, draw in the areas where you might feel thermal discomfort. Indicate how much discomfort with a number from the scale to the right.	Neutral 1	Slightly Warm 2	Noticeably Warm 3	Hot 4	Very Hot 5

FRONT



BACK



Rate the following aspects of thermal comfort:	☹ 1	2	3	😐 4	5	6	☺ 7
Hot Spots	O	O	O	O	O	O	O
Ventilation	O	O	O	O	O	O	O
OVERALL THERMAL COMFORT	**O**	**O**	**O**	**O**	**O**	**O**	**O**

COMMENTS:

Range of Motion

Rate the effect the PPE has on the following motions:	☹ 1	2	3	😐 4	5	6	☺ 7
Shoulder							
- Flexion	O	O	O	O	O	O	O
- Extension	O	O	O	O	O	O	O
- Abduction	O	O	O	O	O	O	O
- Adduction	O	O	O	O	O	O	O
OVERALL SHOULDER MOTION	**O**	**O**	**O**	**O**	**O**	**O**	**O**
Elbow							
- Flexion	O	O	O	O	O	O	O
- Extension	O	O	O	O	O	O	O
OVERALL ELBOW MOTION	**O**	**O**	**O**	**O**	**O**	**O**	**O**
Neck							
- Flexion	O	O	O	O	O	O	O
- Extension	O	O	O	O	O	O	O
- Rotation	O	O	O	O	O	O	O
OVERALL NECK MOTION	**O**	**O**	**O**	**O**	**O**	**O**	**O**
Trunk							
- Flexion	O	O	O	O	O	O	O
- Extension	O	O	O	O	O	O	O
- Lateral Bending	O	O	O	O	O	O	O
- Rotation	O	O	O	O	O	O	O
OVERALL TRUNK MOTION	**O**	**O**	**O**	**O**	**O**	**O**	**O**
Knee							
- Flexion	O	O	O	O	O	O	O
- Extension	O	O	O	O	O	O	O
OVERALL KNEE MOTION	**O**	**O**	**O**	**O**	**O**	**O**	**O**
Hip							
- Flexion	O	O	O	O	O	O	O
- Extension	O	O	O	O	O	O	O
- Abduction	O	O	O	O	O	O	O
- Adduction	O	O	O	O	O	O	O
OVERALL HIP MOTION	**O**	**O**	**O**	**O**	**O**	**O**	**O**
Wrist							
- Flexion	O	O	O	O	O	O	O
- Extension	O	O	O	O	O	O	O
OVERALL WRIST MOTION	**O**	**O**	**O**	**O**	**O**	**O**	**O**
Comments:							

Annex C :
Personal Comments
on Current In-Service PPE

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Driver Comments

*"Crew helmet useless will not protect you. Tac vest catches on everything + cannot carry enough mags/grenades * sling get caught on Tac Vest + frag vest take too long to remove. Easier access to small pack, full zipper around outside maybe, other than that is fantastic"*

"Shoulders pads restrains all movement while overseas, Afghanistan, there is a big need of a different tactical vest. The tactical vest should be able to carry more C-7 magazines, grenades to be in a tan colour and a pouch for first aid kit"

"To hard while wearing all the kit to bend to attach TOW cables. When crawling the ammo pouches would drag on the ground causing more resistance"

Crew Commander and Gunner Comments

"Collar limits looking around with headset on. Throwing grenades is harder due to limit of movement of arms in vest. Handling drill with rifles is harder due to limit of arms in vest"

"The current issued frag vest isn't really mobile especially with shoulder pads on but once they are removed it is something we can work with"

*" IECS jacket too thick * tactical vest too little cargo / carrying space. Body too exposed when firing pintle mount at extremes. Does not allow for "breathing" or "ventilating" during long walks or intense physical exercise. PPE vest too bulky for "gunfight" shooting * PPE vest difficult to remove on casualty"*

Air Sentry Comments

"C7 something to lock the butt to the shoulder. 9mm pistol hard to bring arms together PPE gets hooked on things in vehicle. Hard to change mags in the prone for C6 / C9. Hard to do (vehicle maintenance) with all gear on"

"The kit is ok for dismounted tasks BUT still too heavy in relation to the amount of kit we carry already maneuverability in the kit is great"

*"Carry full kit and manoeuvring through small doors --> bulky * Donning PPE should be all together (molle) Mag C6 / C9 pouches too high. Frag and 40mm need more pouches. Tactical vest should be made of molle. Helmet too heavy"*

"Basically there should be full range of motion, ventilation, all equipment on person to get on with task and proper pouches for person to get tasks done i.e. rifleman grenadier"

"HELMET HEAVY AND OFF BALANCE . Smoke and frag grenade pouch too small. No places for 40mm, 18 rounds. No -place for 521 radio and C6 ammo. Poor placement of 9mm pistol. Changing mags cumbersome, weight placed on legs when firing in kneeling position. Bulky for Attaching TOW cables, changing tires and vehicle maintenance. Carrying full kit and room search and maneuvering through small doors had issues with weight and bulk. Receiving first aid had too many layers"

Physical Discomfort

*"I tighten it to cover my body so the discomfort is my own fault *we are at war it's not about comfort'*

"Slight chaffing around the neck"

"Chafes the neck"

*"Heat rash around neck and armpits * lower back pain caused by the weight"*

"Front plate while bent forward would drive in lower stomach"

"The collar caused some irritation on my neck but tolerable"

"Mostly chaffing for the neck"

"Chaffing slightly at the neck"

*"Chaffing near underarms stationary and while moving * small of back and upper abdomen pinched while sitting"*

"I get pain in left shoulder after extended period of wear"

"It stops bullets so it stops air flow too (breathing constriction)"

"The breathing constriction while NOT moving or performing slight tasks is fine but when under contact it actually kicks in."

*"Chaffing under arms near biceps * vest needs more breathing room (especially with plates) under intense combat"*

Thermal Discomfort

"Heat rash under vest at all times. When moving in armoured vehicle vest is ok for ventilation, but once stopped it is so hot"

"On long patrols sides upper back + lower back would get really hot"

"Hot spots on underarms, very hot on upper chest and back"

"My back was always hot and sore I dealt with it no problem it was just very uncomfortable"

"Back is always exceedingly warm. Too tight to ventilate… if loosened it becomes uncomfortable"

Range of Motion

"Constraining but I wore it all the time. Overall very well thought out design, hinders slightly but the trade off of not wearing one?"

"Shoulder motion is limited when it comes to driving"

"Overall very uncomfortable cannot breed (breath) to hot a lot of rash sometime a rather have less protection but more mobility to do my job"

"Shoulder caps restraint movements. Hot spot around neck. Hard to breath with the flak jacket on"

"For movement in and out of vehicle movement was made easier with shoulder flaps removed"

"Restricted adduction of shoulder due to hard material. Neck seems constricted due to collar portion of the flak vest"

"The collar should be removable due to rubbing with headset and helmet"

"A lighter system for frag vest is needed. A tack vest more inclined towards infantry and more specifically C9 gunner … better load bearing … better load carrying capability"

"Overall trunk motion was restrictive. The key to design all future equipment is ergonomics, light weight, breathable, modular and avoid bulk"

"Shoulder motion w/o pads and neck motion w/o neck piece"

"Shoulder motion w/o the shoulder attachments. Range of motion increase as member gets used to the vest and as the vest breaks in. A brand new vest is limiting, but within a week or two it was fine"

"Vest without shoulder pads. Recommendations are: combine modular system with PPE, more ventilation, better range of motion for neck + trunk AND more compatibility w/ heavy rucks and firing weapon"

Ballistic Coverage Comments.

"Side or torso could use more protection like a small plate. Throat could use a guard but I don't think it would be very feasible in the convey scenario. Neck could also use protection but I also don't think it would be useful in convey. I want to come back home and still be able to make babies, a plate would not work but maybe an extra piece of padding. Llegs would hinder movement"

"Side protection needed. Upper / shoulder protection. Lighter armour. Need something for throat. Need pelvis protection Light weight yet flexible + strong enough"

"As for items rated poorly, they are not currently in service. Should they be? I think it would be more appropriate to ask the battle group pers."

"For groin, pelvis and legs we don't have any protection fro that and I also think it would ***not*** *be beneficial"*

"Some areas are difficult without limiting the soldiers range of motion. Armour for specific tasks such as CC, gunner, house clearing (groin and leg protection), etc."

“Side of torso need it, throat don't have and don't need it. Groin, pelvis and neck (side and back) need it only if static position”

“Throat: no need of protection: need to breath and move your head around. Llower body: need more protection against the blast from IED strikes or mine strike, while in the vehicle no need of leg protection while outside of the vehicle”

“While in vehicle better blast blankets for driver and gunners”

“No current coverage groin + pelvis or legs”

“Throat not req it will limit mobility groin, pelvis, legs not required for crewman. Back ballistic plate req's sturdier pocket so it doesn't fall out the bottom (it gets torn). Neck should be extended about 1 inch. Shoulder pieces should cover arms more and clasp on bicep not vest w/ useful pockets”

“Groin not covered enough, pelvis barely covered and upper arms need more coverage”

“The PPE should have more side protection for armour crew man, due to people shooting at vehicles from the side. Shoulder cap are useless, as they catch on hatches. Have collars removable as they hit on headsets”

“Should get groin protection. Shoulder pads seen to be more of a pain in the vehicle more than anything”

“The vest is designed to cover main organs. We need something lightweight for complete torso coverage that is easy to move around in. No coverage throat”

“In the gunners role most of the time is spent inside the turret and since you need a lot of mobility to access everything your PPE needs to be flexible. Maybe a ballistic plate at the bottom and side of the turret would help for coverage.”

“In service PPE gives very good ballistic protection for the vital organs to the front and rear. The sides only offer fragmentation protection and shoulder offer ballistic as well. There needs to be optional (removable) groin, shoulder protection depending on pers and mission. 40mm need easy access pouches to allow for storage. The issued bandoleer with 40mm is cumbersome and restrictive”

“The use of neck, pelvis and groin would be a good idea. Arm coverage for CC may limit his ability to move both in the turret and while partially exposed”

“Need throat, groin and neck protection. Legs --> not required (cumbersome)”

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INITIATIVE D'EPI POUR LA LUTTE AUX IED − HORIZON 0 PHASE 1 – ANALYSE DE COMPROMIS PRÉLIMINAIRE DE LA PROTECTION PAR RAPPORT AU RENDEMENT ANALYSE COMPORTEMENTALE DES TÂCHES (U)

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Harry Angel; Chris Ste−Croix ; Elizabeth Kittel; Paul Vilhena

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Contract Report

8. SPONSORING ACTIVITY (The names of the department project office or laboratory sponsoring the research and development − include address.)

Sponsoring: DLR 5, NDHQ OTTAWA,ON K1A 0K2

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9b. CONTRACT NO. (If appropriate, the applicable number under which the document was written.)

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(U) DRDC Valcartier has taken the lead on a Counter−IED (C−IED) Personal Protective Equipment (PPE) Horizon 0, which is a sub−project of a larger C−IED Technical Demonstration Project (TDP). DRDC Toronto is the providing Human Factors expertise to support this project. In order to develop PPE recommendations to overcome any change or increase in vulnerability a comprehensive understanding of physiological, biomechanical, task performance and operational impact of increasing coverage and/or level of protection of soldiers needs to be obtained. The objective of this study was to develop a number of operational scenarios that encompassed the majority of tasks performed by mounted crewmen. These scenarios were then used to conduct a behavioral task analysis (BTA) of vehicle crews with emphasis given to reach and viewing activities, physical motions and crew station operations, vehicle and equipment compatibility, and access/egress in normal and emergency situations. The operational scenarios were developed from a focus group held at CFB Edmonton from 1 – 2 February 2007. The four operational scenarios that were developed at the focus group were a quick reaction force in a close country, a broken down vehicle within a city, an engage targets scenario, and a vehicle−borne IED scenario. These
scenarios were then used to lead the BTA that was conducted from 19 – 21 March 2007. A total of 28 soldiers participated in the BTA covering 8 vehicles (G−Wagon, MLVW, HLVW, TLAV, Bison, Leopard C2 Tank, Coyote, and the LAV III). Once the BTA was concluded each participant completed a questionnaire evaluating their current in−service personal protective equipment.
The BTA found that in most vehicle crew positions a full range of motion from the waist up is required, a critical design criteria for any additional PPE developed for vehicle crews. In general, existing PPE was acceptable but concerns were raised about the level of coverage on the sides, neck, throat and pelvis. There were also concerns about the in−service shoulder cap.

(U) RDDC Valcartier a pris le commandement d'une initiative d'équipement de protection individuelle (EPI) pour la lutte aux IED (C−IED) horizon 0, qui est un sous−projet d'un Programme de démonstration de technologie (PDT) de C−IED plus important. RDDC Toronto fournit les connaissances spécialisées en ergonomie pour soutenir ce projet. Afin de formuler des recommandations relativement à l'EPI pour corriger toute augmentation de la vulnérabilité, il faut obtenir une compréhension générale de l'incidence sur la physiologie, la biomécanique, le rendement de tâches et les opérations de l'augmentation de la couverture/de la protection des soldats. L'objectif de cette étude consistait à élaborer un certain nombre de scénarios opérationnels qui comprenaient la majorité des tâches accomplies par les membres d'équipage embarqués. Ces scénarios ont ensuite été utilisés pour effectuer une analyse comportementale des tâches sur les équipages de véhicules qui a mis l'accent sur la portée et les activités de surveillance, les mouvements physiques et les opérations du poste d'équipage, la compatibilité du véhicule et de l'équipement ainsi que l'accès/l'évacuation dans des situations normales et d'urgence. Les scénarios opérationnels ont été élaborés par un groupe de discussion qui a été réuni à la BFC Edmonton les 1er et 2 février 2007. Les quatre scenarios opérationnels qui ont été mis au point par le groupe de discussion sont les suivants : une force de réaction rapide sur un terrain couvert, un véhicule en panne dans une ville, un scénario d'engagement de cibles et un scénario de dispositif explosif de circonstance placé dans un véhicule. Ces scénarios ont ensuite été utilisés pour orienter l'analyse comportementale des tâches qui

a été réalisée du 19 au 21 mars 2007. Dans l'ensemble, 28 soldats ont participé à l'analyse étudiant 8 véhicules (G−Wagon, VLMR, VLLR, VBLC, Bison, char Leopard C2, Coyote et VBL III). Lorsque l'analyse comportementale des tâches a été terminée, chaque participant a rempli un questionnaire qui évaluait leur équipement de protection individuel actuel.

L'analyse comportementale des tâches a conclu qu'une pleine amplitude de mouvements de la taille en montant est requise pour la plupart des postes de l'équipage de véhicule, ce qui constitue un critère de conception critique pour tout EPI supplémentaire développé pour l'équipage de véhicule. En général, L'EPI existant était acceptable mais des préoccupations furent soulevées concernant le niveau de protection sur les côtés, le cou, la gorge et le bassin. Il y avait également des préoccupations concernant l'épaulette présentement en service.

14. KEYWORDS, DESCRIPTORS or IDENTIFIERS (Technically meaningful terms or short phrases that characterize a document and could be helpful in cataloguing the document. They should be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location may also be included. If possible keywords should be selected from a published thesaurus, e.g. Thesaurus of Engineering and Scientific Terms (TEST) and that thesaurus identified. If it is not possible to select indexing terms which are Unclassified, the classification of each should be indicated as with the title.)

(U) Counter−IED; C−IED; Personal Protective Equipment; PPE; Horizon 0; IED Protection; body armour; coverage; protection level